Die

# Vegetation der Erde

Sammlung

pflanzengeographischer Monographien

herausgegeben von

**A. Engler**
ord. Professor der Botanik und Direktor
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XIII

# Phytogeographic Survey of North America

A Consideration of the Phytogeography of the North American Continent, including Mexico, Central America and the West Indies, together with the Evolution of North American Plant Distribution

by

**John W. Harshberger**, A. B., B. S., Ph. D.

Assistant Professor of Botany, University of Pennsylvania; Fellow of the American Association for the Advancement of Science; Member of the Botanical Society of America; Academy of Natural Sciences of Philadelphia; Geographical Society of Philadelphia; American Philosophical Society; &c. &c.

1 Map, 18 Plates and 32 Figures in the text

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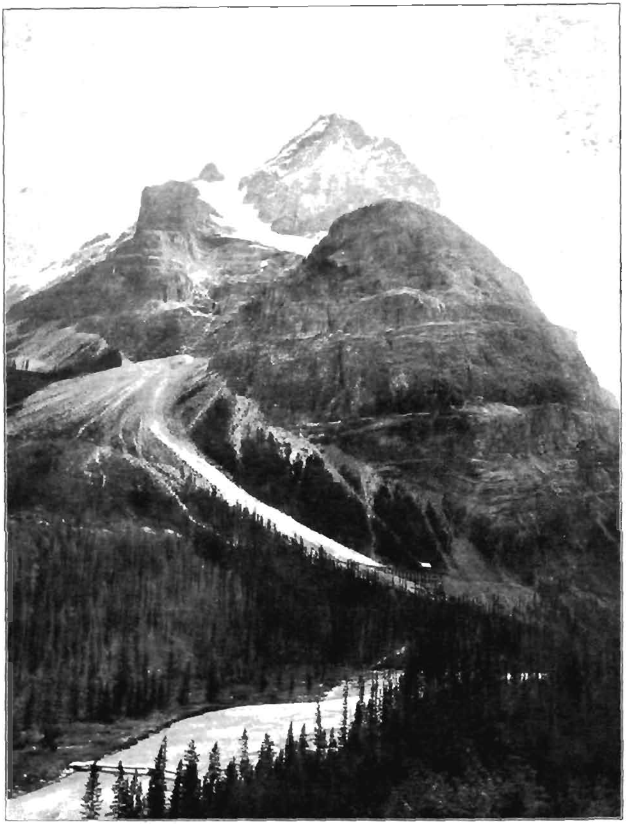

**Mount Stephen**

10520 feet (3207 m) in the Rocky Mountains of Canada from the Kicking Horse River with coniferous forest of spruce Picea Engelmanni Parry.

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Map of North America showing the phytogeographic regions, 18 Plates and 32 Figures in the text

German Extract by **O. Drude**

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# Phytogeographic Survey of North America.

## Preface.

The conservation movement in America had its origin a number of years ago in the agitation to preserve the forests of the nation from total destruction. During the administration of President ROOSEVELT, the movement was given national significance by a meeting in Washington of the governors of the different states, and other prominent men of affairs, to consider whether something could be done to conserve not only the forests, but other natural resources, as streams, mineral products and agricultural soil. This meeting was followed by several conservation congresses in which matters of national importance were given prominence. One of the results of these gatherings of public-spirited men was an inventory of our natural resources made by the scientific bureaus in Washington, aided by the National Academy of Sciences. As a result of this inventory, we know approximately the extent of our forests, the amount of coal which we have for future use, and the location of the oil and mineral deposits.

But with the settlement of the continent and the exploitation of its resources, such as the drainage of its swamps, the removal of the original forests and the construction of irrigation works in arid districts, the original condition of the land surface and its vegetation will be changed forever. It is important, therefore, for this generation of botanists and scientists to leave in printed form, in photographs, in maps and in other illustrations a record of the original appearance of the country before the march of civilization has destroyed primeval conditions. This from the standpoint of the botanist is an important matter, because all future botanic and forestry work must be based on considerations of what was the character of the native growth. Fully recognizing this fact, the writer at the suggestion of the editors of "Die Vegetation der Erde", undertook ten years ago to write a sketch of the Vegetation of North America, and this volume is the outcome of the study of American vegetation, begun over twenty years ago.

During this time trips have been made to all the more important phytogeographic regions of North America, excepting the Arctic tundra, and the itinerary of such collecting trips included the Bermudas, the Bahamas, the Greater Antilles, Mexico, the Pacific coast states, the Rocky Mountains, the prairie

plains, the Piedmont, the Atlantic coastal plain, as far, as extreme southern *Florida* and the *Floridan keys*, the *Dismal Swamp*, the *White*, *Green*, Adirondack, Catskill, northern and southern Appalachian mountains. With the object of leaving in permanent form a description of the native vegetation of North America, various herbaria in Philadelphia and elsewhere have been consulted and correspondence was begun with botanists in various parts of the continent, interested in a phytogeographic, or a systematic study of the flora. A large collection of books and pamphlets has been made, including articles taken from weekly and monthly magazines, and these have been classified for instant use during the prosecution of a work which the author has spared no pains to make as accurate, as the existing state of information and the unfortunate confusion in nomenclature would permit. Details of synonomy, omitted in the lists and in a discussion of the plant formations, are given in the index, while the more important typographic blunders are given proper place.

A collection of photographs, maps and printed illustrations pertinent to American phytogeography has been made during the last few years, and these will be arranged and bound in book form for the future reference of students of American vegetation, when its original state will then be a matter of historic record.

The author wishes to thank most cordially the botanists and scientific friends who have aided him in his work. Many of the societies and individuals, who have given assistance, are mentioned in the bibliography, in the text, and in the footnotes of the illustrations and printed pages throughout the book. Especially, he desires to mention the financial aid given in the printing of the book by the American Philosophical Society out of the Michaux Fund, which as a legacy left to the Society by the French botanist, FRANÇOIS ANDRÉ MICHAUX, has done much to advance the study of arboriculture and for the purchase of botanic books for the library begun by BENJAMIN FRANKLIN.

Finally the author wishes to acknowledge the encouragement and help received from the editors, Professors A. ENGLER and O. DRUDE, and the publishers who have allowed the book to exceed its original limits. He wishes especially to thank Professor Dr. OSCAR DRUDE, who has given much of his time to the revision of the work, while in manuscript and in the press, ably assisted by his daughter Miss HILDEGARD DRUDE (now Mrs. ROBERT HOHLFELD) in the final proof reading of the English text.

University of Pennsylvania
Philadelphia, October 21, 1910.

**John W. Harshberger.**

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# Corrections.

| | | | | | |
|---|---|---|---|---|---|
| Page | 16 | line | 21 | from | top for Grave read Grove. |
| » | 17 | » | 25 | » | » » 1814 » 1841. |
| » | 32 | » | 21 | » | » » D. J. » D. T. |
| » | 34 | » | 3 | » | bottom for A. Pittier read H. Pittier. |
| » | 50 | » | 15 | » | top for Russel read Russell. |
| » | 55 | » | 29 | | » Penshallow read Penhallow. |
| » | 64 | » | 36 | » | » » Feriger read Finger. |
| » | 67 | » | 1 & 2 | » | bottom for Charlestown read Charleston. |
| » | 69 | » | 24 | » | top for Tracey read Tracy. |
| » | 85 | » | 4 | » | » » Jost read José. |
| » | 91 | » | 9 | » | bottom for Cerichona read Cinchona. |
| » | 109 | » | 11 | » | » » (3950 m) read 3810 m). |
| » | 114 | » | 18 | » | top for The read These. |
| » | 117 | » | 4 | » | » » Cookscomb read Cockscomb. |
| » | 217 | » | 9 | » | bottom for ovata read alba. |
| » | 223 | » | 22 | » | top remove sentence beginning "The lower slopes of the Alleghanian". |
| » | 240 | » | 9 | » | bottom for macrophyllum read microphyllum. |
| » | 246 | » | 21 | » | top for P. read S. |
| » | 252 | » | 2 | » | » » capsuli read capuli. |
| » | 267 | » | 23 | » | » » brevifolia read breviflorus. |
| » | 268 | » | 23 | » | » transpose hirta and verna. |
| » | 273 | » | 4 | » | bottom for Eastman read Eastwood. |
| » | 274 | » | 9 | » | top for Loesilia read Loeselia. |
| » | 289 | » | 3 | » | bottom for Prathyrotes read Psathyrotes. |
| » | 298 | » | 12 | » | » » guatemalensis read autumnalis. |
| » | 298 | » | 15 | » | » » mines read ruins. |
| » | 299 | fig | 10 | | for guatemalensis Rose read autumnalis (Eichlam) Rose. |
| » | 333 | line | 9 | from | top for Arnithamnia read Argithamnia. |
| » | 337 | » | 15 | » | » » longifolia read longiflora (Torr.) Don. |
| » | 341 | » | 6 | » | bottom for where read were. |
| » | 349 | » | 25 | » | top for Rhodomenia read Rhodymenia. |
| » | 360 | » | 1 | » | » » Bonz read Bong. |
| » | 366 | » | 3 | » | » » pickered read pickerel. |
| » | 368 | » | 21 | » | » » polygonum read polygamum. |
| » | 370 | » | 26 | » | » » alta read alata. |
| » | 373 | » | 9 | » | » » rudula read radula. |
| » | 383 | » | 9 | » | bottom for Rhodymela read Rhodomela. |
| » | 383 | » | 19 | » | top for siliquosus read siliculosus. |
| » | 383 | » | 25 | » | » » Chordia read Chordaria. |
| » | 391 | » | 10 | » | bottom for retrofacta read retrofracta. |
| » | 395 | » | 7 | » | » » utriculatum read reticulatum. |
| » | 416 | » | 3 | » | top for On read One. |
| » | 424 | » | 18 | » | bottom for parviflora read parvifolia. |
| » | 424 | » | 19 | » | top for polygonum read polygamum. |

Page 427 line 22 from top for Paronichia read Paronychia.
» 442 » 12 » » » denominated read dominated.
» 444 » 25 » » » Compoet read Compact.
» 452 » 14 » » » obtusifolia read obtusiloba.
» 456 » 13 » » » » » »
» 465 » 31 » » » extend read extended.
» 481 » 1 » » » a read as.
» 482 » 20 » delete (,; and for Thelypteris read thelypteris.
» 485 » 33 » top for pauciflora read paucifolia.
» 490 » 13 » bottom transpose alba and tomentosa.
» 499 » 17 » » for natans read nutans.
» 501 » 4 » top for parvifolium read parviflorum.
» 502 » 4 » » » nudiflora read nudicaulis.
» 520 » 7 » » transpose odorata and microcarpa.
» 524 » 13 » » for ohioennis read ohionis.
» 531 » 27 » » » taxiflora read laxiflora.
» 531 » 28 » » » virginiana read americana.
» 545 » 7 » » » tracbysperma read trachypleura.
» 545 » 29 » » » strictus read striatus.
» 549 » 13 » » » erythocarpum read erythrococcum.
» 550 » 30 » » » » » »
» 550 » 36 » » » glandulifera read glanduliflora.
» 551 » 1 » bottom for Jock read Jack.
» 558 » 12 » top for Rugelii read Regelii.
» 560 » 14 » bottom for gysophila read gypsophila.
» 564 » 24 » » » where read were.
» 573 » 23 » top for Robbensii read Robbinsii.
» 574 » 13 » bottom for thomy read thorny.
» 576 » 32 » top for ciliosa read ciliaris.
» 580 » 18 » bottom for pinion read piñon.
» 581 » 2 » top remove and.
» 582 » 5 » *top for that read the.*
» 583 » 3 » » » mountains read maintains.
» 583 » 5 » » » Calogania » Cologania.
» 583 » 18 » » » stenophyllus read stenosepalus.
» 586 » 20 » » » Fransera read Franseria.
» 590 » 16 » » » laetiflorum read lactiflorum.
» 597 » 22 » » delete (= M. urceolaria Salisb.).
» 608 » 2 » » for Ceanothus read Cercocarpus.
» 608 » 27 » » » There read They.
» 616 » 11 » bottom for Bay read Pass.
» 618 » 13 » top for so read to.
» 623 » 24 » » » Hespereaea read Hesperelaea.
» 625 » 6 » » » A. read O.
» 654 » 20 » » » (.) after pines place (,).
» 663 » 1 » bottom for Calwert read Calvert.
» 676 » 30 » top for member read number.
» 680 » 14 » » » Blakeo read Blakea.
» 694 » 23 » » » Raponia read Rapania.
» 694 » 25 » » » Phalanthus read Philanthus.
» 695 » 4 » » » humeliaefolia read bumeliaefolia.
» 695 » 8 » » » humelia read Bumelia.

# Kurzgefaßte deutsche Inhaltsübersicht

von

Prof. Dr. **O. Drude.**

Als die Herausgeber in Übereinstimmung mit dem Verleger beschlossen, zur Gewinnung eines weitergehenden Kreises auserlesener Mitarbeiter auch Abhandlungen in englischer und französischer Sprache unter die Bände der »Vegetation der Erde« aufzunehmen, wurde zugleich bestimmt, daß in diesen Fällen ein deutscher Auszug beigegeben werden sollte, welcher den in fremden Sprachen weniger Bewanderten die Übersicht, das Auffinden der leitenden Gesichtspunkte erleichtern und die Einteilung des Stoffes in anderer Weise übermitteln sollte, als es die Inhaltsangaben des Verfassers selbst tun. Zugleich ist hier Gelegenheit gegeben, die Entstehung solcher Abhandlungen zu erklären und Bemerkungen hinzuzufügen, welche auch im Sprachgebiet des Verfassers als nützlich empfunden werden mögen.

Ein Jahrzehnt etwa ist über der Herausgabe dieses »*Phytogeographic Survey of North America*« verstrichen, eines Werkes, das Prof. Dr. JOHN HARSHBERGER zuerst »*The Plant Formations of North America*« in Betonung des Schwergewichts von Teil IV (S. 346—704) benennen wollte. Als ich im Sommer 1904 die Freude des persönlichen Zusammentreffens mit dem Verfasser zu gemeinsamen Wanderungen und Kongreßverhandlungen hatte, die mich 4 Mal nach Philadelphia brachten, lag dort bereits der Kartenentwurf im großen Maßstabe und ein umfangreiches Manuskript, welches wir dann im Sommer 1907 als vollendet durchsprechen konnten; sein erster Abschluß war bereits im September 1906 erfolgt. Wenn trotzdem verschiedene Umstände bewirkten, daß erst im November 1908 das »Imprimatur« zum ersten Bogen erteilt wurde und in der Drucklegung größere Pausen wegen des Einganges wertvoller Nachträge, zumal auch einer Reihe ausgezeichneter Landschaftsbilder, entstanden, so hat das schließlich, wie ich mit dem Verfasser hoffe, doch nur zur Abrundung des Ganzen und zur Durchführung des Zweckes, ein »Survey« zu sein, gedient.

Vor allem muß ich dabei dankbar der unbeschränkten Freiheit gedenken, welche Prof. HARSHBERGER uns Herausgebern über sein Manuskript einräumte, um es in den für das Buch vorgesehenen Grenzen von 40 Bogen englischem Text zu halten, welche — z. T. durch die wertvollen Abbildungen, z. T. durch unentbehrliche Zusätze noch während des Druckes von Abschnitt IV —

nur wenig überschritten sind. Es ist meine Pflicht hervorzuheben, daß besonders in den Einzelheiten der Formationsskizzen nach Auszügen aus Literatur wie nach den eigenen Aufnahmen des Verfassers eine starke Kürzung von etwa 10 Bogen Textlänge mit Zustimmung des Verfassers stattgefunden hat, und daß nach Möglichkeit die nicht systematisch oder sonstwie in Listenform geordneten Aufzählungen in engem Satz in den Haupttext eingeschaltet wurden, um die Übersichtlichkeit zu erleichtern.

Sodann muß auch hier hervorgehoben werden, daß zur Beigabe einer großen Zahl trefflicher Illustrationen nicht nur kostbare Originale in großem Format zur Verfügung gestellt wurden, sondern daß in Philadelphia dem Verfasser zu den dadurch verursachten höheren Verlagskosten ein Beitrag übermittelt wurde (s. englisches Vorwort S. VI).

Prof. HARSHBERGER kennt sein Gebiet aus vielen Reisen, kreuz und quer und in vielen Jahren gemacht, von der Westküste bis zur Mündung des St. Lorenz, in den Alleghanies wie Felsengebirgen, im mexikanischen Hochlande und auf den Antillen. Nur das weite Gebiet nördlich vom 50° NB. und die tropische Region von Zentralamerika hat er nicht bereist, und es sind demzufolge auch die betreffenden Kapitel im IV. Abschnitt (I. S. 346—360 und IV. S. 657—672) am kürzesten ausgefallen, da sie nur in dem groß ausgespannten Rahmen nicht zu fehlen hatten. Immer mehr stellt sich bei der Herausgabe dieser Einzelbände die Notwendigkeit heraus, daß die Bearbeiter größerer Ländergebiete auch ein zusammenfassendes Urteil über diejenigen Landschaften vortragen, deren Natur und Pflanzenwelt sie nach der ihnen bekannten Umgebung besser verstehen können, als die meisten, welche bisher aus der darüber veröffentlichten Quellenliteratur sich ein eigenes Urteil zu bilden gezwungen waren. Es läßt aber überhaupt dieser »Survey« die Herausgabe späterer Bearbeitungen von hervorragenden Sektionen des wundervoll reichen, hier zusammengefaßten Ländergebietes frei.

**Nomenklatur.** Prof. HARSHBERGER schloß sich auf Wunsch der Herausgeber im allgemeinen an die in den »Natürlichen Pflanzenfamilien« zum Ausdruck gelangte Nomenklatur an und folgte also hinsichtlich der amerikanischen Species der von TORREY und ASA GRAY, SERENO WATSON, ENGELMANN, CHAPMAN u. a. durchgeführten Namensgebung, deren Hauptwerke meist unter den General Works in der *Bibliography* S. 46 ff. angeführt sind. Der Wunsch, auch der neueren Strömung in amerikanischer Nomenklatur gerecht zu werden — (Arbeiten von BRITTON, GREENE, MAC MILLAN, SMALL, SARGENT und vielen anderen, die bei allem inneren hohen Wert doch für die Namengebung das hervorgerufen haben, was die Freunde einer konservativen Nomenklaturrichtung Verwirrung und unnütze Erschwerung des Verständnisses älterer Quellenliteratur nennen) — führte den Verfasser zur Anwendung einer unausgesetzten Synonymik, welche dann aber doch in der Drucklegung nicht zum Ausdruck gelangte, außer wo es im Einzelfalle notwendig erschien; sie wurde vielmehr in das mit großer Sorgfalt von HARSHBERGER zusammengestellte Register verwiesen. Es würde tatsächlich für das Studium des Lesers höchst störend empfunden sein,

wenn derselbe immerfort die Synonyma in Parenthese gefunden hätte, wie z. B. bei Alsine = Arenaria = Ammadenia = Honkenya peploides; nur bei manchen wichtigen Arten, besonders bei den herrschenden Bäumen der Formationen, erschien die Doppelbezeichnung auch im laufenden Texte angebracht. Die Verwirrung, welche in manchen Fällen droht, ist tatsächlich sehr bedauerlich, wofür als Beispiel auf die beiden *Tsuga*-Arten des Westens, (S. 547 Anm. 2) hingewiesen werden mag.

**Englische Maße, Temperaturgrade.** Es war selbstverständlich, daß der englische Text zunächst die in den Vereinigten Staaten üblichen Maße, *miles* und *square miles* an Stelle von Kilometern und Quadratkilometern, anwenden mußte. An den wichtigen Stellen sind dieselben umgerechnet in Klammern beigefügt; wo dasselbe unterblieb, genügt für rasche Umrechnung folgende Verhältniszahl:

mile : km = 16 : 10; squaremile : qkm = 10 : 4;
oder 1 mile = 1,61 km; 1 squaremile = 2,6 qkm.

Die Höhen sind in allen Fällen in englischen Fuß angegeben und da, wo es darauf ankommt, genau umgerechnet in Meterangaben daneben zu finden. Bei allgemeineren Angaben, also z. B. Höhenstufen abgerundet *1200—2000* **Fuß**, ist folgerichtig auch die Umrechnung nach Metern willkürlich abgerundet worden; meist aber bleibt sie in diesen Fällen dem Leser selbst überlassen, wofür ich folgende kleine Hilfstabelle hier einstelle, um dem Leser das Nachschlagen in anderen Büchern zu ersparen:

| | | | | | |
|---|---|---|---|---|---|
| *1000 feet* | = *305 m* | *(ca. 300 m)* | *6000 feet* | = *1829 m* | *(ca. 1830 m)* |
| 2000 » | = 610 » | (» 600 ») | 7000 » | = 2134 » | (» 2130 ») |
| 3000 » | = 914 » | (» 900 ») | 8000 » | = 2438 » | (» 2440 ») |
| 4000 » | = 1219 » | (» 1220 ») | 9000 » | = 2743 » | (» 2740 ») |
| 5000 » | = 1524 » | (» 1520 ») | 10000 » | = 3048 » | (» 3050 ») |

Wenn sich auch im klimatischen Abschnitt (S. 130—165) viele Einzelangaben und sogar Tabellen (S. 156, 160) von Fahrenheit-Graden in Celsius umgerechnet finden, so mußten doch die ausführlicheren Tabellen ohne solche Umrechnung in Satz kommen. Für diese mag hier die übliche Vergleichstabelle gleichfalls in kurzem Auszuge Platz finden, welcher vom Minimum — 13,1° F. (S. 136) bis zum Maximum 95° F. (S. 151) Auskunft gibt:

| | | | | | |
|---|---|---|---|---|---|
| — 13° F. | = — 25° C. | 51,8° F. | = 11° C. | 68° F. | = 20° C. |
| — 4 » | = — 20 » | 53,6 » | = 12 » | 69,8 » | = 21 » |
| — 0,4 » | = — 18 » | 55,4 » | = 13 » | 71,6 » | = 22 » |
| + 5° » | = — 15 » | 57,2 » | = 14 » | 73,4 » | = 23 » |
| 14 » | = — 10 » | 59,0 » | = 15 » | 75,2 » | = 24 » |
| 23 » | = — 5 » | 60,8 » | = 16 » | 77 » | = 25 » |
| 32 » | = ∓ 0 » | 62,6 » | = 17 » | 86 » | = 30 » |
| 41 » | = 5 » | 64,4 » | = 18 » | 95 » | = 35 » |
| 50 » | = 10 » | 66,2 » | = 19 » | | |

Zum Vergleich der Niederschlagshöhen und Schneetiefen (S. 137) dient folgende kleine Tabelle:

| | | |
|---|---|---|
| 1 mm = 0,04 inches | 60 mm = 2,36 inches | 300 mm = 11,81 inches |
| 5 » = 0,20 » | 70 » = 2,76 » | 400 » = 15,75 » |
| 10 » = 0,39 » | 80 » = 3,15 » | 500 » = 19,69 » |
| 20 » = 0,79 » | 90 » = 3,54 » | 600 » = 23,62 » |
| 30 » = 1,18 » | 100 » = 3,94 » | 800 » = 31,50 » |
| 40 » = 1,57 » | abgek. = 4,0 » | 1000 » = 39,37 » |
| 50 » = 1,97 » | 200 mm = 7,87 » | (= ca. 40 inches). |
| abgek. = 2,0 » | | |

## Gliederung des Kontinents. Geographischer und floristischer Charakter der einzelnen Teile.

Bei der Bearbeitung seines gewaltigen Stoffes behält HARSHBERGER stets dieselbe Reihenfolge von der arktischen Zone bis zu den Tropen in Westindien bei, wenngleich die Einteilung in den verschiedenen Abschnitten so gewählt ist, wie sie sich der Darstellung am besten darbot.

Die floristische Durchforschung von Nordamerika ist zunächst historisch (Part I, S. 1—39) in einer die Staaten zur Grundlage nehmenden Einteilung geschildert, nämlich 1. Canada einschl. Alaska und Britisch-Columbia (S. 1—7), 2. Neu-England (S. 7—11), 3. die mittleren atlantischen Staaten (New York, New Jersey, Pennsylvania, Delaware S. 11—16), 4. die südöstlichen Staaten (Carolina, Virginien, Georgia, Florida, Louisiana S. 17—18), 5. die Prärien, Wüstensteppen und Felsengebirge (S. 18—24), 6. die Staaten an der pacifischen Küste der Union bis Californien (S. 24—29), 7. unter dem Titel »Great Southwest« das nordwestliche Texas, Neu-Mexiko, die Mohave-Wüste von Californien, Arizona und die Errichtung der Station Tucson durch die Carnegie-Institution (S. 29—30), 8. Mexiko (S. 30—33), 9. Zentralamerika von Guatemala bis Costa Rica und Panama (S. 33—35), 10. Westindien (S. 35—39), und die Werke der in diesem gedrängten Abschnitt genannten Reisenden und Botaniker, deren Titel die unter 8 Sektionen gegliederte Bibliographie (S. 46—92) unter Vermeidung von Wiederholungen genau ordnet, sind es hauptsächlich, auf welche sich unsere heutige Florenkenntnis von Nordamerika stützt. Es folgt dann S. 39—45 noch eine kurze Ergänzung für die Literatur nach eigentlichen pflanzengeographischen Gesichtspunkten, welche sehr viel spärlicher gesät ist, wie ja auch tatsächlich der jetzt vorliegende »Survey« des Verfassers die erste ganz Nordamerika zum Ziel nehmende pflanzengeographische Monographie ist, einen so wichtigen Anteil dieser Kontinent auch an dem Lehrstoff der Handbücher und Erdatlanten von jeher besaß. Von großer Bedeutung ist dann (Part II, Chapter 1 und ff.) der geographisch-klimatische und floristische Überblick über die ganze Ländermasse von der Arktis bis zu den Tropen. Die hier gebrauchte Einteilung in vier — sagen wir »Gebiete« —

soll diesem Auszuge zugrunde gelegt werden, um die in dem großen Schlußabschnitt (Part IV, S. 346—704) enthaltenen eingehenden floristischen Schilderungen an die kurze Skizze vom physiographischen Aufbau des ganzen Landes und der Inseln anzuknüpfen. HARSHBERGER nennt dieselben: 1. das Nördliche Gebiet (*Northern division*, S. 95), 2. das Mittlere Gebiet (*Central division*, S. 102), 3. das Südliche Gebiet (*Southern division*, S. 113, mit Mexiko und Zentralamerika), 4. Westindien (*West Indies in general*, S. 121), von St. Croix bis zu den Bermudas. Es ist dies eine Gliederung in großen Zügen, welche das Verständnis der Vegetationszonen und -regionen vorbereitet, ohne deren spätere genauere Einteilung zu stören. Ein Blick auf die Karte mit der regionalen Farbengebung belehrt sogleich darüber, daß das Mittlere Gebiet, welches von 50° N. südwärts noch den 30. Parallel überschreitet, das am meisten gegliederte ist, was auch in dessen strenger Unterteilung sich scharf ausdrückt.

Zunächst aber ist des **Aufbaues des ganzen Kontinents** (S. 93) zu gedenken, der darin seine Hauptzüge findet, daß zwei unter sich völlig getrennte und auch ganz und gar ungleichartige Gebirgssysteme seinen Charakter bestimmen, das Appalachensystem im Osten und das Kordillerensystem im Westen, zwischen welchen beiden ein riesiges Bassin sich befindet, dessen Wässer vom Mackenzie in das Eismeer, von den großen Seen durch den St. Lorenz in den Nordatlantischen Ozean, endlich vom Mississippi in den Golf hinabgeführt werden. So geht von der Keewatin-Niederung westlich der Hudson-Bai bis nach Louisiana, vom Polarkreise bis über den 30° N. noch weit südwärts hinaus eine tiefe Depression, welche größtenteils unter 200 m liegt und nur in Ontario nördlich der großen Seen, sowie auf der schwachen Wasserscheide in Illinois und Indiana gegen den Mississippi, diese niedere Höhe mit Plateaus und Rücken von höheren, aber 500 m nicht übersteigenden Stufen überschreitet.

Hochplateaus, Bergketten und Gipfel von mehr als 1000—1500 m Höhe finden sich demnach nördlich des St. Lorenz nur auf Baffinland und Labrador, südlich des St. Lorenz dagegen von Neu-Braunschweig und Maine südwärts bis Alabama, und dieses appalachische Bergland fällt nach Westen zum Mississippi-Bassin ab, während es im Osten und Süden von einem niederen Küstenstreifen jüngeren Landes umsäumt wird, einer breiten Ebene, an welche sich der »Piedmont Belt« (das Fußhügelland) anschließt mit unterer Grenze an der »Fall-Linie«, welche über Philadelphia und Washington bis Columbia in Süd-Carolina streichend, die beginnenden Stromschnellen der Flüsse anzeigt, welche der Schiffahrt hier ein natürliches Ende bereiteten.

Die mächtige Entwicklung des Kordillerensystems im Westen, vom Behrings-Meer bis nach Panama, ist der bekannteste Zug im Aufbau des nordamerikanischen Kontinents, auch sein Streichen so nahe der Küste des Stillen Meeres, daß die Mehrzahl der westwärts gehenden Flüsse kurzen Lauf und wenig Sammelfläche haben, mit alleiniger Ausnahme des in den Puget Sund mündenden Columbia-Flusses. Langsam erhebt sich am Unterlauf des Arkansas und Missouri das Land auf die Prärien tragende Höhenstufe von 500—1000 bis

1500 m, dann steigt das Hochgebirge an; dasselbe Bild haben wir am Saskatchewan, Athabasca- und Peace River.

Da diese beiden Hauptkerne des Kontinents in eigener, voneinander sehr abweichender Geschichte sich entwickelt und erst im Tertiär zum jetzigen Nordamerika sich vereinigt haben, so liegt darin auch die floristische Verschiedenheit begründet, welche die Gebirge und Küsten auf der atlantischen wie auf der pacifischen Seite so hervorragend zeigen. Der Golf von Mexiko ist der eingeschränkte Rest eines großen inneren Sees zwischen der Appalachen- und der Kordilleren-Bergmasse. Die hohen Gebirge der Antillen schließen sich in ihrer Richtung an das Kordillerensystem südlich von Tehuantepec an, welches ostwärts streichend die Halbinsel Yucatan durchsetzt.

## 1. Nördliches Gebiet.

**A.** Gemäß dem vorhin besprochenen Grundcharakter baut sich die nördliche Masse desselben auf: a) im Osten aus dem Laurentischen Plateau, welches, die Hudson-Bai von drei Seiten umfassend, die größere Hälfte Canadas mit Urgneis, wechsellagernden Graniten und den sedimentären huronischen Schichten bedeckt, in der Diluvialperiode ganz eisbedeckt war, und ein welliges Hügelland meist in der Höhenstufe 200—500 m darstellt: die nordischen Tundren der »Barren grounds«; — b) von der Westgrenze des laurentischen Plateaus am Winnipeg-See bis zum Ostfuß der Rocky Mts. aus einer inneren Hochebene von Kreide- und Tertiärschichten gebildet, welche die Ausläufer der südlicheren Prärien tragen (S. 96), umgürtet von nordischen Wäldern; — c) aus dem nördlichen Kordillerensystem, welches die kanadischen Rocky Mts., eine innere Hochebene und dann die pacifische Küstenkette mit im Westen tief eingeschnittenen Tälern bildet. Nördlich vom Kontinent liegt der mächtig ausgedehnte arktische Archipel, aus alten Formationen vom Silur bis Karbon gebildet, von einem undurchdringlichen Wall von Packeis umgeben, zu dessen Pflanzengeographie dieses Werk keinen neuen Beitrag bringt [1]. HARSHBERGER gedenkt des mächtigen Mackenzie River, des längsten Stromlaufes in Nordamerika nach dem Mississippi (S. 96), der Halbinsel Labrador (S. 97), der Insel Neu-Fundland, dann des Distrikts von Alaska am Beringsmeer, an der Küste aus Tundra bestehend, mit dem hier mündenden großen Strom Yukon (S. 98, 99). Leider sind in dem klimatischen Kapitel von Canada (S. 135—138) über diese nördlichen Distrikte keine speziellen Stationsnachweise enthalten, indem die kälteste Station, White River in Ontario, im Januar mittlere Minima von —25° C, zusammen mit mittleren Maximis von kaum —10° C aufweist, Monatsmittel etwa —17° C.

Die bisher besprochenen Territorien sind auf der farbigen Karte als die der Arktischen Zone (Tundra und verwandte Formationen, Farbe braun-

1) Die Pflanzengeographie der Arktis wird später von Dr. PORSILD und Dr. OSTENFELD gemeinsam bearbeitet werden; das arktische Europa mit Nowaja Semlja ist bei Dr. R. POHLE in Bearbeitung für die »Vegetation der Erde«.

violett) und die der Subarktischen (Hudsonian-) Zone mit dem nördlichen Coniferenwalde bezeichnet (Farbe hellgrün, darin die Vegetationsgrenzen von *Larix americana*, *Populus balsamifera*, *Betula papyrifera* und *Abies balsamea*). In Abschnitt IV ist Kapitel 1 (S. 346—360) der Schilderung ihrer Flora und ihrer Formationen gewidmet, dabei auch der Unterschied in der Flora des östlichen arktischen Amerikas gegenüber dem westlichen (mit künstlicher Grenze) S. 347 genannt und eine Tabelle zusammengestellt, welche die 35 nicht in Westgrönland aufgefundenen Arten von arktisch-amerikanischen Blütenpflanzen nennt. Diese Zahl ist nicht gering, aber es sind darunter manche wenig bedeutende Arten, welche wie Glyceria fluitans, Solidago, Artemisia, Caltha einfach weiter vorgeschobene Posten der Kontinentalflora darstellen. — Die Tundrenformation hat eine eingehendere Schilderung aus Alaska erfahren (S. 348, mit Taf. 7).

Bei dem großen Interesse, welches die weitgedehnten »Barren grounds« in der Dominion von Canada haben und den geringfügig in neuerer Zeit über sie erschienenen Mitteilungen, ist es am Platze, ergänzend auf das ältere — unzweifelhaft beste — Quellenwerk v. J. 1851 hinzuweisen, Sir J. RICHARDSONS Reisewerk durch das britische Nordamerika bis zur arktischen Küste (Franklin-Expedition, 2 Bd. von zusammen 839 Seiten, s. Bibliography p. 55).

Es schildert die Senke der Rocky Mts. aus dem Quellgebiet des Athabasca unter 53° N von 2450 m Höhe zu niederen Ketten (1000 m) unter 62° N, wo sie längs des Mackenzie nirgends mehr ewigen Schnee tragen, und hier beginnen dann an ihrem Ostfuße unmittelbar (ohne Zwischenschaltung von Prärien) die großen, bis zum Atlantischen Ozean reichenden Tiefebenen; durch eine enorme Menge von Landseen erscheinen sie so sehr zerklüftet, daß die Fläche von süßem Wasser hier größer erscheint als die des trocknen Bodens. Dabei taut aber der Boden unter 62° N (Fort Simpson) im Sommer über 3 m tief auf und der Eisboden bildet eine nur etwa 2 m dicke Schicht. Diese Verhältnisse ändern sich bedeutend gegen die Hudson-Bai hin, welche mit ihren Eismassen eine ständige Kältequelle, zumal bei Beginn des Frühlings, darstellt. Daher steigen auch alle Vegetationsgrenzen von der südlichen Umrandung der Hudson-Bai gegen das Mündungsgebiet des Mackenzie um etwa 12 Breitengrade an, so daß die Waldgrenze hier etwa am Polarkreise vom Bereich der endlosen arktischen Tundren abgelöst wird. Auf der dünnen Erdschicht über dem granitischen Detritus gedeihen besonders begünstigt die Strauchflechten (*Cornicularia tristis*, *Bryopogon ochroleucum*, *Cetraria cucullata*: alle drei auch im Riesengebirge Deutschlands!, daneben die gewöhnliche *C. islandica* u. a.), bald für sich allein, bald mit Zwergsträuchern vergesellschaftet, deren kurze Zweige kaum aus dem Lichenen-Teppich hervorragen: diese Zwergsträucher scheinen dieselben Arten zu sein, wie die S. 348 für Alaska genannten, nur *Kalmia glauca* kommt hinzu. — Außer diesen Flechtentundren entwickeln sich an feuchteren Gehängen Staudenmatten von Saxifraga-, Pedicularis-, Primula-Arten, es finden sich Sanddünen ähnlich wie die S. 350, Abs. 2 geschilderten mit *Lathyrus maritimus*, zu dem *Polemonium coeruleum* und *Dodecatheon* kommt,

Wiesen in geschützter Lage mit *Elymus mollis* und *Spartina cynosuroides*, endlich an den Flußufern eine höhere Strauchformation vornehmlich von *Salix speciosa*, deren Areal MACOUN angibt vom Mackenzie R. und Dean R., auf den höchsten Gipfeln der canadischen Rocky Mts., im östlichen Canada nördlich des Polarkreises, Kotzebue-Sund und Nushagak in Alaska, Liard R. unter 60° N.

HARSHBERGER teilt die subarktische Waldregion von Nord-Canada und Alaska in den Labradordistrikt (S. 351) mit sich daran anschließendem Neu-Fundland, wo *Juniperus communis* auftritt (S. 354), in den Hudson Bai-Keewatin-Distrikt, dessen Seen- und Flußuferformationen zu den vorher geschilderten borealen Wäldern treten, in den Mackenzie-Distrikt (S. 356) mit Nadel- und Espenwaldungen von *Populus balsamifera* und wo die ersten Prärienausläufer mit *Opuntia missouriensis* sich finden, und in den Alaska-Distrikt (S. 358), wo in den nördlichen Rocky Mts. *Pinus Murrayana* für *P. Banksiana*, und *Abies subalpina* für *A. balsamea* eintritt, sonst aber der gleiche Waldcharakter herrscht bis zu den Besonderheiten des Küstenstrichs am Stillen Ozean.

**B.** Was nun noch an Territorien von HARSHBERGER unter dem Nördlichen Gebiete auf S. 99—102 zusammengefaßt wird, gehört gemäß den herrschenden Formationen und den Vegetationsgrenzen von *Pinus Strobus* (»White Pine«), der fast ebensoweit vordringenden *Ulmus americana* und dem mit seiner Nordgrenze den Lake Superior durchschneidenden Zuckerahorn (*A. saccharinum* = *saccharum*) im Osten zu der St. Lorenz- und Großen Seen-Region, deren Flora den Beginn der Schilderungen der temperierten Zone in Kapitel II (S. 360) bildet, während im Westen (unter Versparung der nördlichsten Prärien auf ein späteres Kapitel) schon die Besonderheiten der pacifischen Küstenflora und des Kordillerensystems weit nach Norden ausgreifen und dort die Sitka-Vegetationsregion als nördlichste, außerdem die nördlichen Territorien der Rocky Mts.-Region und der Region von Britisch-Columbia bilden, deren Grenzen auf der Karte mit einem Blicke zu übersehen sind. Es sind dies also gewissermaßen Übergangsregionen, welche den stark ausgeprägten borealen Charakter mit den besonderen Elementen der mittleren nordamerikanischen Flora, welche in der atlantischen Laubwaldflora einen ganz anderen Ausdruck findet, in Verbindung setzen und welche die politische Grenze zwischen Kanada und den nördlichen Unionsstaaten überbrücken.

Diese Gegenden des britischen Besitzes sind es hauptsächlich, deren Klima die meteorologischen Tabellen nach dem Canadian Meteorologic Service 1903 (S. 136—137) anzeigen, wobei die Mittelwerte sofort aus der hinzugefügten Kolumne mit den Abweichungen vom Mittel zu ersehen sind. Es ist der Kürze wegen das Verfahren eingeschlagen, nur je einen für den Jahreszeitenwechsel maßgebenden Monat herauszugreifen, diesem aber die Niederschläge und Höhen auch für die folgenden beiden Monate hinzuzufügen. Zur Übertragung in Celsiusgrade und Millimeterniederschlag bediene man sich der vorn (S. XV—XVI) gedruckten Hilfstabelle. — Die Stationen sind von Ost nach West geordnet, mit Neu-

Fundland beginnend, Ontario und Manitoba in der Mitte, Alberta ist die Landschaft am Westfuß der Rocky Mts., 3 Stationen in Britisch-Columbia machen den Schluß und zeichnen sich durch milde Winter (Mittel des Januar schwankend zwischen $-5°$ C. und $+5°$ C.) neben kühleren Sommern aus (Julimittel 11° C. bis 19° C.), während die mittleren Maxima des Juli in dem ganzen Gürtel zwischen 17° und 26° C. liegen. Beachtenswert sind bis in den Mai hinein die bedeutenden Schneetiefen.

Die geographische Übersicht hebt unter »Pacific Range« zunächst die hohen Küstengipfel in Alaska hervor (S. 99) und schließt eine Skizze der canadischen Rocky Mts. an, deren drei nebeneinander liegende Ketten zwischen 49° und 52° N. skizziert werden (S. 100). Dieser Gegend entstammt das Titelbild mit dem Mt. Stephen; der Kicking Horse-Paß liegt etwa unter 51½° N. in 1600 m Höhe. Die floristische Schilderung dieses nördlichen Teiles der »Rocky Mountain Region« geschieht S. 546—551 (Northern Dominion-District) unter Hinweis auf die früher (S. 244—250) in Listen zusammengestellten Bäume und Sträucher. Nadelholzwald mit *Pseudotsuga*, *Tsuga* und *Thuja*, eine subalpine Formation von *Abies subalpina* und oberhalb 1830 m die Hochgebirgsformationen mit *Ranunculus Eschscholtzii*, *Dryas* und *Sibbaldia* (S. 551) sind das am meisten hervorzuhebende.

Die Gebiete des Fraser River und des oberen Columbia (S. 100) führen dann zu der Küsten- oder Cascadenkette über, welche mit der sich anschließenden Niederung in die nach dem Flusse benannte südliche Columbiaregion und die mit der Nordhälfte der Vancouverinsel beginnende Sitkaregion geteilt ist; die letztere endet erst nördlich vom 60° N. an den eisbedeckten Hochbergen von Alaska, und von diesem interessanten Gebiete gibt Tafel XIV mit dem Davidsongletscher eine hübsche Ansicht (S. 587), wo der Küstenwald aus den herrschenden Coniferen dieser Region die Gletscherzungen umsäumt. In dem mit diesem Bilde beginnenden Kapitel 4 sind die floristischen Einzelheiten über die genannten Regionen (S. 587, 592) zu finden, welche aus Britisch-Columbia zum Staate Washington südlich der Vancouverinsel überführen (siehe unten, mittleres Gebiet, pacifische Sektion).

Zum Schluß (S. 100—102) geht die geographische Übersicht wieder ostwärts zurückkehrend auf das Große Seengebiet über und verweilt bei dem einzigartigen Stromgebiet des St. Lorenz, dessen Tal im Norden von dem Laurentischen Hügellande umgeben wird, 300 bis gegen 500 m hoch mit einzelnen 700 m überschreitenden Erhebungen. Südlich vom St. Lorenz haben wir auch noch in Canada die Ausläufer des Appalachen-Bergsystems, welches die Fortsetzung der »Green Mts.« von Vermont bildet. — So beginnt mit diesen Territorien in Kapitel II (Atlantische Sektion der Temperierten Zone von Nordamerika) die spezielle floristische Schilderung derselben. Sie teilt die breit gedehnte Region des St. Lorenz und der Großen Seen (S. 360) in einen a) Maritimen Distrikt mit dem Bezirk Neu-Braunschweig (S. 361), schildert darunter die bemerkenswert nordischen Floren der höheren Berge in Neu-England, des Mt. Katahdin in Maine (1590 m) mit Liste der alpinen

Arten (S. 372) und des Mt. Washington (1932 m) mit Wald von Nadel- und Laubhölzern und reichen alpinen Formationen (S. 373—377), endlich die des Mt. Mansfield (S. 377—378), und fügt den Bezirk Neu-England (S. 378—390) an; in diesem erfolgt auch ein genaueres Eingehen auf Moore, Wasserpflanzen und sogar die ozeanische Algenflora (S. 383—385).

Daran schließt sich b) der Seendistrikt südlich der Vegetationslinie der *Ulmus americana* (»White elm«), der nun schon ganz in die nächste Abteilung, die »Central division« entfällt.

## 2. Mittleres Gebiet.

Die geographische Übersicht beginnt mit der östlichen Sektion, dem Appalachischen System (S. 102), geht zu den Bergketten und Hochebenen des Kordilleren Systems über, und endet mit den Landschaften des »Great Valley«, d. h. der Talsenkung des Mississippi und seiner Nebenflüsse (S. 112), gemäß dem oben (S. XVII) Gesagten.

Über diese, die politische Grenze der Union ausfüllenden Landschaften, deren besondere Literatur in der Bibliographie unter Sektion II—VI (S. 56—82) ausführlich zusammengestellt ist, sind auch eingehende klimatologische Nachweise im Abschn. II, Kap. 2, S. 138—148, gegeben, welche sich an Canada (S. 135—138) anschließen und deren tabellarische Zusammenstellung von 28 Stationen die Temperaturen im Mittel, mittleren Maximum und mittleren Minimum für jeden einzelnen Monat enthalten.

Da die Stationen in der alphabetischen Ordnung zum Zweck leichter Auffindbarkeit stehen und da ihre geographische Lage nach dem Namen des Staates, dem sie angehören, beurteilt werden kann von Massachusetts bis Georgia, Neu-Mexiko und Florida, so habe ich eine vorderste Kolumne für je zwei zusammengefaßte Monate beigegeben, in welcher eine Ordnungsziffer die Stationen entweder nach dem Durchschnittsminimum (Januar, März, November), oder nach dem Durchschnittsmaximum (Juli), oder endlich nach der Durchschnittstemperatur schlechthin (Mai, September) ordnen läßt.

So hat fast immer die Station Key West, Florida, als Nr. 28 den höchsten Rang mit Januar 63° F. = 17° C. Minimum, März 68° F. = 20° C. Minimum, Mai 78,5° F. = 26° C. Mittel, September 82° F. = 28° C. Mittel, November 70° F. = 21° C. Minimum, wird aber in den Julitemperaturen (als Nr. 25 im Range) geschlagen von New Orleans mit 88° F. = 31° C., von Dodge City in Kansas mit 89° F. = 31,5° C., und endlich von Savannah in Georgia mit 89,3° F. = 32° C. als mittleren Maximaltemperaturen.

Die kälteste Station nach dem Winterminimum vom November und März ist die Stadt Bismarck in Norddakota (Januarmittel — 12,5° C.), aber die mittleren Minima des Januar sind am tiefsten in Havre, Montana, mit fast — 17° C. und fast ebenso tief in St. Paul, Minnesota. In der Ordnung nach dem Julimaximum hat Station Bismarck sogar die 13. Stelle mit etwa 28° C., so daß der extreme Klimacharakter der nördlichen, an der Ostabdachung der Kordilleren gelegenen Landschaften hierdurch eine scharfe Beleuchtung erfährt.

Diese aus den Tabellen in persönlicher Arbeit zu entnehmenden Beispiele erhalten durch die allgemeinen Bemerkungen von HARSHBERGER den richtigen Rückhalt (S. 139), wo er hinsichtlich der Temperatur besonders die Berechnung der Gradienten vom Golf nach Nordosten im Januar und den Vergleich der niederen Sommertemperaturen an der pacifischen Küste bespricht. Als tiefste Temperaturen sind in Montana und Dakota — 48,3° C. und — 51,1° C. beobachtet, als höchste Temperaturen im Wüstendistrikt 48° C. an einer regulären Station Yuma, sonst noch 50° C. und 53,3° C. — Von ganz besonderer Bedeutung sind dann selbstverständlich die Besprechungen der Niederschläge und Luftfeuchtigkeit (S. 144—148). An sechs verschiedenen Strichen überschreitet der Regenfall in einigen Monaten 6 ins. = 150 mm, nämlich im nordwestlichen Washington (Oktober), in Alabama und Mississippi (Januar bis März), im nordöstlichen Texas (April—Mai), im nördlichen Missouri (Mai—Juni), am Küstenstrich von Kap Hatteras (März—Oktober), und endlich im Bereich der subtropischen Regen von Florida (Juni—Oktober). Die Minima der Monatsniederschläge sind ebenso unregelmäßig verteilt und umfassen merkwürdigerweise nicht so viel Landschaften im Südwesten als vielmehr in Neu-England, Michigan, Texas; die Wüstensteppen verdanken ihren Charakter dem Streichen der Gebirge und ihrer Lage an deren Leeseite, welche zu einer außerordentlichen Dürre in den Frühjahrsmonaten führt[1]).

**A). Östliche Sektion mit dem Appalachensystem.** Die Küste der Atlantischen Staaten ist nördlich von Kap Hatteras (35° N.) eine stark zerfurchte mit tief einschneidenden Buchten und kanalartigen Meeresarmen: sie ist fjordartig gestaltet; vorgelagerte Sandinseln und Sanddüne, wie sie sich südlich der Neu York-Bai findet, bilden den Küstencharakter in Carolina, Georgia und Florida; der niedere, flache Küstencharakter setzt sich dann am Golf von Mexiko fort, besonders am Delta des Mississippi. Oberwärts der Fall-Linie gegen den Atlantischen Ozean folgen dann die »Piedmont plateaus« (S. 103), darauf die Bergketten der Appalachen, die in langem Zuge von SW nach NO oder NNO streichen bis zu dem Querbruch, den im Staate Neu-York der Hudson R. und der Mohawk R. hervorrufen, so daß eine Senke von nur 46 m genügen würde, um auf dem Wege des Lake Champlain an der Ostseite der Adirondacks den Ozean mit dem Tal des St. Lorenz zu verbinden. Dieses Gebirge mit Höhen bis 1638 m (S. 104) erhebt sich isoliert; jenseits der genannten Senke des Hudson folgen die Green- und White Mts., deren floristische Verschiedenheit nicht nur aus ihrer nördlicheren Lage, sondern erst recht aus ihrer geographischen Isolierung verständlich wird.

Die Appalachenkette selbst (von ihrer Nordspitze, den Catskill Mts., an) gliedert sich in ein System östlicher Kämme, die Blue Ridge, in ein vielfach gefaltetes Tal, das »Great Valley«, welches in Pennsylvanien und Virginien

1) Für kurzen Gebrauch enthält die Sammlung Göschen, Bd. 381: H. FISCHER, Landeskunde der Vereinigten Staaten von Nordamerika, auf S. 46 eine sehr übersichtliche Regenkarte mit Hervorhebung des Jahreszeitenwechsels. Siehe auch SCHIMPERS Pflanzengeographie, Karte I und II.

landschaftlich sehr ausgeprägt ist, und in ein System von Bergen und Hochflächen, welches man als Alleghany-Plateau zu bezeichnen pflegt. Die Blue Ridge bildet in Carolina die Hauptwasserscheide zwischen Atlantischem Ozean und dem Tieflande des Mississippi und erreicht im Grandfather Mt. mit 1817 m die größte Höhe (S. 105). Darauf aber erhebt sich in dem Unaka Range das Gebirge noch zu größerer Durchschnittshöhe mit vielen Gipfeln zwischen 1200—1520 m und einigen höher als 6000 F. = 1830 m. Diese höchsten Ketten sind die Black Mts., welche im Mt. Mitchell 2045 m hoch ansteigen, 113 m höher als Mt. Washington (siehe oben, S. XXII), so daß die höchsten Punkte der atlantischen Bergketten sich in fast gleicher Höhe auf den Norden in Neu-England und auf den Süden in Carolina verteilen.

Hier knüpft nun die floristische Bearbeitung mit dem Distrikt der Großen Seen an, welchen HARSHBERGER einteilt in den a) Interlacustrinen Bezirk (S. 390—403), dessen Süßwasser- und Uferformationen, z. B. in Michigan, ein hervorragendes Interesse bieten, und in b) den Bezirk der Adirondacks (S. 403 bis 408). Dieses Gebirge läßt sich in Höhe, Ausdehnung und auch noch einigermaßen im borealen Florencharakter mit den schlesisch-böhmischen Sudeten vergleichen, hat an den Rändern und im Inneren tief eingeschnittene Seen (Tafel VIII, S. 404), deren Steilufer über einem Gürtel strauchiger Erlen mit dem Mengwald von Weißbirke, *P. Strobus*, höher *Tsuga*, *Betula lutea* usw. bedeckt sind, während die Fichtenformation von *Picea rubra* mit Tannen und *Sorbus americana* die Höhenstufe des Waldes bildet. Die nicht umfangreichen nackten Gipfelfelsen über 1550 m tragen neben Mooren mit *Kalmia* und *Ledum* eine reiche Flora (S. 406), darunter prachtvolle Polster der *Diapensia lapponica* (Tafel II auf S. 188). Zum Vergleich sei bemerkt, daß die Waldgrenze auf Mt. Washington bei 1220 m Höhe liegt; auf sie folgt aber zunächst ein Krummholz aus verkrüppelten Fichten (*Picea nigra*) mit *Alnus viridis*; auf Mt. Tahawus der Adirondacks besteht es aus *Abies balsamea*; *Cornus canadensis* (Tafel II unten) ist in der mittleren und oberen Nadelwaldregion aller dieser Gebirge eine in dichten Massen vorkommende, im Hochsommer prächtig in roten Früchten prangende Staude.

Es folgt nun die Küstenregion der Atlantic und des Golfes, eine mächtige, in Form eines Hufeisens die Appalachen umlagernde Vegetationsregion, welche von Rhode Island und New-Jersey südwärts bis zur Tropenregion von Florida reicht und dann im südlichen Alabama, Louisiana, Missouri und Arkansas bis über St. Louis nach Norden hinauf zum Ohio reicht. Die gelbgrüne Schraffierung auf der Karte soll sie als ein subtropisches, von Xerophilen durchsetztes Gebiet kennzeichnen, und das sind besonders die Bewohner der »*Pine Barrens*« in Verbindung mit Salzstrand und Dünen an der Meeresküste (S. 408—460).

Diese auf 52 S. ausführlich geschilderte Region, welche in dieser Weise nebst der folgenden (Piedmont-Appalachian-Ozark) in einer für die nordamerikanische Kartographie neuen Weise die östliche und westliche Abdachung des Appalachensystems um dessen langgestreckte Achse zusammenfaßt, zerfällt bei

der großen von ihr umfangenen Territorialmasse in vier natürliche Distrikte: A. Nördlicher Pine Barren-Küstendistrikt (S. 409—426), B. Carolina Pine Barren-Küstendistrikt (S. 427—443), C. Golf Pine Barren-Küstendistrikt (S. 443—453), und D. Arkansas Louisiana-Distrikt, der letzte als einziger, welcher nur über die Mississippiniederung hinweggeht, ohne die Meeresküste zu berühren.

Ausführlich werden die Salzstrand- und Dünenformationen geschildert, welche mit Kiefernwäldern in Anschluß stehen, worüber Tafel IV (S. 222) eine sehr gute landschaftliche Vorstellung gibt, ebenso, was einzelne Baumformen anbetrifft, Fig. 24 auf S. 417 und Fig. 25 auf S. 418; die dichten Buschwälder im Andrängen gegen eine Sanddüne, oder umgekehrt, erläutert Fig. 23 auf S. 414. Eine Menge interessanter, aus echt atlantisch-nordamerikanischen Arten bestehender Assoziationen werden aufgeführt, welche leicht an ihren Stichworten in Sperrdruck aufzufinden sind. Die *Pine Barren*-Formation in ihrer wechselnden Zusammensetzung (siehe unten S. LVI in dem den Formationen gewidmeten Abschnitt dieses Auszuges) beansprucht naturgemäß das Hauptinteresse, zumal sie der Region den Namen gegeben hat (siehe S. 420, 434, 446, 448, 459).

Dazu kommen aber zumal im südlichen Teile dieser Region noch die höchst bemerkenswerten Sumpfwaldungen und Beigemische von Palmen, welche gleichfalls in den Illustrationen beredten Ausdruck gefunden haben. Tafel VI (S. 306) zeigt das interessante Gemisch von hochragender *Pinus caribaea* (*cubensis*!) mit dem wie die europäische Zwergpalme in Granada erscheinenden Gestrüpp von *Serenoa serrulata*; vom Arkansas Louisiana-Distrikt zeigt Fig. 5 (S. 213) die Sumpfwaldungen der Sumpfcypresse: *Taxodium distichum*, mit *Nyssa* gemischt, zu denen S. 454 die ausführliche Beschreibung gegeben ist; eine ähnliche Formation, in welcher aber Laubbäume (*Nyssa*, *Acer*, *Fraxinus*, *Quercus phellos* mit *Liquidambar*) überwiegen, schildert S. 439 mit Tafel X; endlich ist die höchste subtropische Entwickelung dieses atlantischen und Golf-Charakters in der *Palmettoformation* zu suchen, welche bei Kap Fear, Nord-Carolina, ihre Nordgrenze erreicht und von dieser Stelle in Tafel IX (S. 433) eine Illustration gefunden hat.

Das Studium der farbigen Karte lehrt, daß eine Menge von wichtigen Vegetationslinien grade in dieser Vegetationsregion verläuft, welche ja auch die Ausdehnung zwischen 30° N und 40° N noch beiderseits überschreitet. Gegenüber den Versuchen, hier eine Einteilung der Regionen nach einzelnen solcher Charakterarten, besonders der Palmen, zu machen, hat HARSHBERGER es vorgezogen, auf andere verbindende Züge in diesem reichen Artgemisch hinzuweisen und die wichtigen Nebenbestandteile mehr beiläufig als Unterscheidungen sekundärer Art aufzuführen: dadurch erhält auch seine pflanzengeographische Hauptkarte eine bestimmte Tendenz. Wie man auch immer kartographische Gebietsabgrenzungen ausführt, sie werden stets daran leiden, daß man einem Prinzip andere Gesichtspunkte unterordnen muß; nur darum kann es sich also handeln, welches Prinzip als das vornehmste zu betonen ist, und darüber kann nur jemand entscheiden, der das Land aus eigener

jahrelanger Anschauung kennt und viele Vergleiche in weitem Umfange durchgeführt hat.

Fast ganz umspannt das Areal von *Liriodendron* diese Region, geht allerdings im Norden darüber bis zu den Großen Seen hinaus und bleibt im Golfgebiet noch weit von der Küste zurück; *Magnolia glauca* hat fast gleiche Nordgrenze, und mit dieser fallen hier ungefähr (abgesehen vom höheren Berglande) die Südgrenzen von *Pinus Strobus* und *Betula papyrifera* zusammen; *Yucca* und *Pinus palustris* folgen nach Süden mit Nordgrenze etwa 36—37° N, dann folgt *Sabal Palmetto*. Florida ist dadurch sehr bemerkenswert, daß eine Reihe wichtiger Südgrenzen (dargestellt sind auf der Karte *Nyssa aquatica*, *Pinus palustris* und *Taxodium distichum*) mit der Nordgrenze der Tropenformationen zusammenfällt, von denen nur an der Küste die von *Rhizophora Mangle* angegeben ist. Natürlich stellen die Palmen, *Sabal Palmetto* u. a. A., ein verwandtschaftliches Glied des antillanisch-floridanischen Tropenelements dar.

Für die reiche Waldflora, die diese Region in den Laubwaldformationen außerhalb der Herrschaft von *Pinus* kennzeichnet, mag auf die S. 456 gegebene Liste vom Wabashtal in Illinois aus dem Inlanddistrikt hingewiesen werden.

Es folgt nun die nächste, von dem Hufeisen der Pine Barren-Strandformationen umschlossene Bergregion vom Piedmont-Appalachian-Ozarkplateau (S. 460—516), welche naturgemäß in drei Distrikte sich gliedert: die Vorberge des Appalachensystems verteilen sich auf die östliche (atlantische) Abdachung der Hauptketten und auf die westliche, welche breit vom Michigan-See und dem Erie-See im Norden bis gegen 32° N im Süden diesen Ketten vorlagert und inmitten vom Ohio entwässert wird. Die atlantische Abdachung bildet den Piedmontdistrikt (S. 460—473), die zum Mississippital gewendete den Alleghany-Ozarkdistrikt (S. 497—516). Die hohen Bergketten selbst zwischen den beiden eben genannten Distrikten werden als Appalachen-Distrikt (S. 473—496) zusammengefaßt und gliedern sich, wie übrigens auch die beiden ersten, in einen nördlichen und südlichen Bezirk.

Es ist zweckmäßig, zunächst die, die meisten borealen Elemente aus den nördlich um die Großen Seen sich ausbreitenden Territorien einschließenden Bergketten des Appalachendistrikts zu charakterisieren, dann erst die atlantische Abdachung folgen zu lassen und zum Schluß den Alleghany-Ozarkdistrikt, der schon nach Westen und Nordwesten von den Prärien der »*Great Plains*« umrandet wird.

Appalachen-Bergsystem (vgl. S. XXIII—XXIV). Es besteht dasselbe aus vielen, der Länge nach parallel zur Hauptachse des Gebirges von SW nach NO nebeneinander hinstreichenden Ketten, welche unter sich von tiefen Tälern geschieden sind mit einzelnen Querdurchbrüchen. Von allen Hochpunkten des Gebirges erscheint dieses gleiche Bild, landschaftlich sehr schön und durch den prachtvollen, fast alle Kämme ununterbrochen deckenden Wald in ein mannigfaltiges Grün getaucht. Es ist bemerkenswert, daß die älteren deutschen Handbücher und Atlanten für dies Gebirge zumeist nur den — auch in diesem

Buche sehr viel eingeschränkteren — Sammelbegriff der Alleghanies führen; aber die sich hier sehr zahlreich zusammenfindenden, typisch atlantisch-nordamerikanischen Florenelemente werden richtig als appalachisch bezeichnet. — Die Grenze zwischen dem nördlichen und südlichen Gebirgsbezirk setzt HARSHBERGER etwa in das südliche Virginien: hier nämlich fließt der New River (Great Kanawha) aus einem Längstal die Kette nach NW durchbrechend in den Ohio, und ebenso gehen südlich von ihm alle Hauptströme durch den Mississippi in den Golf, während nördlich davon die Flüsse im Alleghany-Hochplateau von West-Virginien und Pennsylvanien entspringen und mit südostwärts gerichtetem Laufe, wobei sie in tiefen Schluchten (»water gaps«) die Ketten durchbrechen, den Atlantischen Ozean erreichen (S. 474). Der bedeutendere Teil des Gebirges ist der südliche, während der nördliche in Pennsylvanien am Susquehanna R. (S. 475) und in den Catskill Mts. von New York (S. 479—481) sehr gut botanisch untersuchte Territorien umschließt; Tafel XI (S. 465) zeigt zwei kleinere Landschaftsbilder, von denen das untere mit dem Tsuga-Walde hierher gehört, das obere zum Piedmontdistrikt. Die Waldflora beansprucht naturgemäß das Hauptinteresse, *Strobus*, *Tsuga*, *Pinus rigida*, die höchsten Stufen (1000 m) mit *Abies balsamea*, dazu prächtiger Laubwald von vorwiegend *Quercus alba* und *Castanea*.

Der südliche Appalachenbezirk (S. 482—496), welcher also vom südlichen Virginien bis zu dem nördlichen Alabama reicht, gliedert seine Formationsschilderungen nach zwei Höhenstufen; die niedere reicht von 460—900 m, wo sich Kiefernwälder (*P. mitis* = *echinata*, *rigida* und *inops*) mit reichen Laubwäldern von Eichen (*Qu. alba*, *coccinea*, *Prinus*, *tinctoria*, *marylandica*) und *Castanea*, *Oxydendrum* und den *Carya*-(*Hicoria*-)Arten mischen, mit *Acer*, *Juglans*, *Liriodendron* u. a. A. (S. 483—486). Für den prachtvollen hier herrschenden Wald standen dem Verf. gerade keine neuen Abbildungen zur Verfügung, welche die darüber vorhandene reiche Literatur ergänzt hätten. Es sei daher auf das mit 76 Tafeln in groß 4° fast nur landschaftlicher Art geschmückte Werk: Report of the Secretary of Agriculture (1902) ausdrücklich verwiesen, welches S. 70 der »Bibliography« unter dem Stichwort »ROOSEVELT« angeführt ist, da es als Botschaft des Präsidenten erschien und die Anlegung eines großen Nationalparkes im Gebiet von N.- und S.-Carolina, Tennessee und Virginia vorbereiten sollte. Die Landschaftsbilder hier (z. B. Taf. XVII) geben den Charakter des Gebirges trefflich wieder, bunte und schwarze Reproduktionen zeigen das reiche Gemisch der Baumarten und die Massenhaftigkeit des nach oben hin dichten *Rhododendron*-Gürtels. Die Baumliste dieses Bezirkes nennt nicht weniger als 13 Nadelhölzer, 11 Walnuß- und Hickorybäume, 15 Eichen, 20 Arten anderer Kätzchenbäume, 7 Magnolien, 12 Ahorn, Linden und Aesculus, 6 Eschen, 6 Leguminosen, 25 Rosaceen u. a., zusammen 133 Arten. Und in diesem reichhaltigen Gebiete, mit (neben Ost-Asien) dem schönsten arktotertiären Walde der Welt, sind in den Wintermonaten tiefste Temperaturen von — 28° C. sogar in niederen Höhen von 500—600 m beobachtet worden, während die Sommerhitze bis auf 38° C. steigen kann! —

Die obere Stufe wird besonders vom Roan- und Grandfather Mt. geschildert (S. 487—489); die Eichen nehmen hier ab, *Acer spicatum*, *pennsylvanicum*, *saccharum* mit *Castanea*, *Prunus pennsylvanica* und *Sorbus americana* nehmen zu, *Picea nigra* (= *mariana*) und *Tsuga canadensis* bilden obere Gürtel. Die unter 36° N. liegenden höchsten Erhebungen, welche subalpine Formationen tragen, sind mit der Skizze der Cumberland Mts. in Verbindung gebracht, welche von Tennessee bis zum nördlichen Alabama streichen (S. 489—496) und so zu der Pine Barren-Region überleiten. In den niederen Höhen von 300—400 m (Sand Mt., S. 491) ist ein zusammenhängender Wald von offenem Charakter, Laubbäume (Eichen, Hickory, Kastanie und Tulpenbaum) gemischt mit *Pinus mitis* und *Taeda*.

Auf den östlichen Ausläufern der Alleghanies in Alabama decken Wälder von *Pinus palustris* die trocknen Felsrippen krystallinischer Gesteine bis 600 m Höhe, um oberwärts durch Eichen und Hickory ersetzt zu werden (S. 493). Die montanen Coniferenwälder aber beginnen höher, auf dem Black Mountain Range unterhalb 1600 m, und bestehen aus *Picea nigra* und *Abies Fraseri* mit Ahorn, Birken, Ebereschen (S. 492); *Veratrum*, *Vaccinium*, *Menziesia*, *Trillium*, *Clintonia* finden sich mit *Rhododendron catawbiense* zusammen, während im nördlichen Bezirk *Rhod. maximum* vorherrscht (S. 485).

Dieser Nadelwald erstreckt sich ohne Ablösung durch eine subalpine Formation bis zum Gipfel des Mt. Mitchell (2045 m S. 493), wo sich zwischen die windzerzausten Fichten und Tannen wiederum *Betula lutea* und *Prunus pennsylvanica* mischen, dazu *Rh. catawbiense*; ganz ähnlich auf dem Grandfather Mt. und Roan Mt., während auf dem Big Frog Mt. *Pinus Strobus* mit *mitis* und *Tsuga* waldbildend auftreten. Auf Grandfather und Roan kommt eine Niederbuschformation von Ericaceen (*Leiophyllum buxifolium* und *Rhod. catawbiense*-Assoziation) vor, Grünerlen mit einigen borealen Elementen, *Potentilla tridentata*, *Saxifraga leucanthemifolia* (S. 495—96).

Piedmontdistrikt (S. 460—473). Die Schilderung hebt zunächst nochmals die Bedeutung der Fall-Linie (s. S. XVII) hervor, welche McGee als eine der am stärksten ausgeprägten physiographischen und kulturellen Linien bezeichnet, da sie die Lage der großen Hauptstädte des Ostens bedingt hat. Dementsprechend zeichnet sich auch die Flora scharf von der der Küstenebene mit ihrem Pinetum ab und gipfelt im Laubwald-Charakter mit reichem Strauch- und Kräuterwuchs (S. 461).

Der nördliche Bezirk hält sich besonders an das südöstliche Pennsylvanien am Delaware R. mit Sümpfen und Teichen, Laubwäldern (Abh. S. 467 zeigt den riesigen Wuchs der Liane *Vitis aestivalis*) und der Hemlockformation (S. 469). Der südliche Bezirk hat die Präponderanz mancher neuer Arten voraus (*Magnolia umbrella*, *Cornus florida* u. a., S. 471); auch die Arten der Eichen wechseln, wie man sich überhaupt hüten muß zu glauben, daß die große Zahl von Eichenarten, die in den europäischen botanischen Gärten nebeneinander aushalten, in gleicher Mannigfaltigkeit in einem einzelnen Territorium zu finden wäre. Es wechseln mit den Eichen (S. 472) auch zum Teile die

Stauden; denn trotz der großen Längenerstreckung des Appalachensystems von den südlichen Neu England-Staaten bis zum mittleren Georgia zeigt sich doch noch zum mindesten noch die Hälfte der Species als beiden Vegetationsregionen gemeinsam (S. 472). So endet die Piedmontflora südwärts am Tallapoosa- und Coosafluß in Alabama, und eine kleine Liste nennt wichtige Species von entschieden nördlichem Areal, welche hier ihre Südgrenze finden (S. 473).

Alleghany- Ozarkdistrikt (S. 497—516). Dieser Distrikt ist recht groß, indem er vom Südrande des Michigan- und Eriesees östlich vom Mississippi bis Alabama, westlich des Mississippis aber auch noch weit über das Tal des Missouri hinaus in das südliche Texas hinein sich erstreckt. Er zerfällt demnach in drei natürliche Teile, a) den Seenbezirk mit Landschaften, welche sämtlich nördlich vom Ohiofluß liegen, b) den Kentucky-Tennessee-Bezirk, entlang und südlich vom Ohio bis Alabama, und endlich c) in den Ozark-Plateaubezirk, welcher nur durch einen schmalen Verbindungsstreifen und durch Übergangsterritorien in Illinois mit dem Bezirk a) zusammenhängt, sonst selbständig dasteht und seinerseits die Golf-Küstenregion (Pine Barren) am unteren Mississippi im Westen breit umrandet. Geographisch trennt daher dieser letzte Bezirk die Prärien in Texas und Kansas von der Pine Barrens-Region, und, da an seinem südwestlichen Ende auf dem Edwards Plateau ein interessantes »Meeting« für Arten der Atlantischen-, der Mexikanischen- und der Rocky Mts.-Region gegeben ist, so entsteht die Frage, ob nicht dieser Bezirk (wenn auch mit den Merkmalen einer Mischlingsregion) besser zu einer eigenen Vegetationsregion erhoben werden sollte. Harshberger hat diese Auffassung dadurch erleichtert, daß er diese »Ozark Area« mit besonderer Umgrenzung und im Übergangston trefflich sich abhebender Farbe herausgehoben hat (s. Karte: Signatur 12 für die Waldlandschaften in Grün); ja auch das Edwards Plateau hat unter den Wüstensteppen seine besondere Markierung erhalten.

Die besondere Schilderung der Formationen beginnt (S. 797) mit Hervorhebung der verschiedenen Vegetationsbedingungen von Bezirk a) und b): sie behandelt die an den Südküsten der Großen Seen demnach allein hier, soweit es diese Region anbetrifft, anzutreffenden See-, Seeufer-, Sanddünen-, Sumpf- und Moorformationen (S. 498—500), die ihren selbstverständlichen Anschluß an die gleichen Formationen der St. Lorenz- und Seenregion im Norden finden. Der Waldcharakter (S. 501) führt dann zum Vergleich mit dem Kentucky-Tennesseebezirk, dessen Waldkleid in lehrreichen Listen (S. 503—4) ausführlich behandelt ist mit Skizzen von den Anteilen einzelner hervorragender Baumarten darin. *Fagus* und *Liriodendron* sind hier nebeneinander noch stark vertreten; in der Liste fehlen auch *Pinus Strobus* und *Tsuga canadensis* nicht als Zeichen des borealen Charakters (S. 509), *Asimina* und *Lindera* mit *Nyssa* als Zeichen des warmtemperierten Charakters. Die Pine Barrens der südlicheren Niederung finden hier einen gewissen Ersatz in der Rotceder-Formation von *Juniperus virginiana* (S. 507, 509), während die feuchten Schluchten sich durch eine Ansammlung hübscher Farne auszeichnen (S. 508); der südliche Teil heißt

das Cumberland Plateau. Das **Ozark Plateau** ist von diesem Cumberland Plateau durch große Absenkungen geschieden, bildet übrigens in seiner ideellen Verbindung mit dem östlichen Alleghany Plateau etwa da, wo der Ohio in den Mississippi mündet, ein zwischen die bis zur Ohiomündung nach Norden auslaufende Küstenebene des Golfes und das »Great Valley«, die großen Ebenen mit den Prärien, eingeschobenes, selbständiges und dadurch für die Kartographie der Vegetationsgrenzen recht wichtiges Glied. Die geographische Konfiguration beschreibt HARSHBERGER S. 112, gleichzeitig mit der Lage der Prärien.

So beginnt die eingehendere Schilderung mit der Darlegung der floristischen Verhältnisse des Staates Missouri (S. 510), der tatsächlich eine recht interessante Mittelstellung in den vorher genannten Territorialgrenzen einnimmt. *Quercus obtusiloba* wird als ein Charakterzug für das Ozarkplateau genannt, während manche atlantische Species der Appalachen hier selten werden. So zeigt denn überhaupt die Zusammensetzung der Wälder mit *Quercus platanoides* und *texana* neun Fazies an, von denen auch die »Blue Beech« genannte (S. 512) und die »Blue Ash« von *Fraxinus quadrangulata* auf dem Hügellande, die Ulmen- und Lindenfacies (»Basswood«, *Tilia americana*) mit Sumpfeichen (*Qu. palustris, platanoides, macrocarpa*) für die Tieflandswälder charakteristisch sind. *Sassafras, Juglans cinerea, Betula nigra* und *Tecoma radicans* erreichen hier ihre Westgrenze (S. 513); auch andere Vegetationslinien lassen sich mehr oder weniger bestimmt bezeichnen, wo die Untersuchung des Landes (neuerdings durch DANIELS) schon weit genug vorgeschritten ist.

So werden diese Arealstudien bis zum Rio Grande Fluß in Texas ausgedehnt (S. 514) und die Formationen auf nassen und trocknen Felsen, die hier noch einmal von besonderem Interesse sind, hinzugefügt (S. 515).

**B). Westliche Sektion mit den Rocky Mountains und den Küstengebirgen.** Die geographische Übersicht beginnt die Skizzierung der Verhältnisse, auf welchen sich die Vegetationsformationen der sehr verschiedenartig gegliederten Westhälfte aufbauen, mit den Felsengebirgen (S. 106), knüpft daran das westlich dieses Hochgebirges liegenden Columbia Plateau und die wüstenhaften, südwärts zum Colorado und Rio Grande del Norte entwässerten Hochflächen des Colorado Plateau (S. 108), geht zur Skizze der in der Sierra Nevada gipfelnden Küstengebirge mit Wasserscheide gegen den Stillen Ozean über (S. 109), und schließt mit dem »Great Valley« (S. 112), in welchem, wie wir wissen, die Längsfurche zwischen dem atlantischen Osten und dem pacifischen Westen nach dem Golf von Mexiko ausläuft.

Die Schilderung der floristischen Verhältnisse in diesen Territorien, — die vielleicht nach meiner Meinung Anspruch auf den Titel eines eigenen Florenreiches haben, welches man dann (mit Zuziehung der nordmexikanischen Hochflächen) bis zu seiner Südgrenze vor den tropischen Elementen das **Sonorische Florenreich** mit dem von MERRIAM[1]) dafür gebrauchten Titel nennen könnte —,

1) Siehe Bibliography S. 49. — Ich beziehe mich aber hauptsächlich auf eine Karte von MERRIAM, welche im Report of Division of Ornithology and Mammalogy, U. S. Departm. of Agriculture Dec. 1893 mitgeteilt ist.

diese Schilderung also verteilt sich im vierten Abschnitt auf Kap. III (S. 516—587) für die xerophytischen Vegetationsregionen des Innern, und auf Kap. IV (S. 587 bis 633) für die pacifischen Küstendistrikte. Die Zweiteilung dient nicht nur der Übersichtlichkeit, sondern sie entspricht auch völlig der Sache; denn der Umstand, der z. B. in meinen früheren Arbeiten über die Florenreiche der Erde hauptsächlich hinderlich war, das Sonorische Florenreich als ein selbständiges aufzustellen, ist von höchster Bedeutung, daß sich in den pacifischen Distrikten, schmal hingestreckt von Californien bis zu 60° n. Br., die floristischen Verhältnisse des Seengebietes und der Appalachen großenteils mit einem ganz veränderten, neuen Reichtum an Arten wiederholen, in welchem die Coniferen eine mächtig führende Rolle innehaben. Dieser Küstenstrich würde also bei einer dies berücksichtigenden Florenreichseinteilung ein pacifisches Gebiet des mittleren nordamerikanischen Waldlandes darstellen, welches durch den mächtigen Keil des Sonorischen Florenreichs von den Schwestergebieten der atlantischen Sektion abgetrennt erscheint. HARSHBERGER ist auf diese Fragen direkt nicht eingegangen, aber er hat zu ihrer Behandlung (namentlich in der formellen Behandlung seiner Regionen) ein wesentlich bereichertes Material beigebracht.

Die floristische Literatur zu der ganzen, so reich gegliederten Ländermasse westlich vom Mississippi und dem Ozarkdistrikt findet sich für die Rocky Mts. und die inneren xerophytischen Vegetationsregionen unter *Bibliography*, Sect. IV und V (S. 71—78), für die pacifischen Küstenregionen unter Sect. VI S. 78—82).

In der geographischen und floristischen Durchforschung der nordamerikanischen Union spielt der 100° w. L. eine große Rolle; ganze Florenverzeichnisse, welche eine neue Ära begründen halfen, führen die Bezeichnung »westlich vom hundertsten Parallel«. Derselbe schneidet mitten durch Dakota, Nebraska, Kansas und Texas, schneidet dabei auch, wie ein Blick auf HARSHBERGERs Karte zeigt, mitten durch dessen mächtige, im Gelb klar sich heraushebende »Region der Großen Prärie-Ebenen«, welche in ihrer Ausdehnung vom 30° n. Br. bis über den 60° n. Br. eine riesenhafte Vegetationsregion darstellt, wie sich die subarktische Waldregion in ähnlich weiter Erstreckung über die nordischen Flächen zwischen den ganzen Längengraden vom Yukon bis Neu-Fundland erstreckt.

Diese Prärien liegen in ihrer Abdachung gegen das »Great Valley« auf sehr verschiedener geologischer Unterlage, indem im Norden sehr alte, im Süden sehr junge Schichten sich ablösen. Indem aber unter niedrigen Breiten westwärts von den Ozarkbergen immer ältere Schichten (Tertiär, Kreide) an die Oberfläche treten und unter höheren Breiten immer jüngere, treffen schließlich Schichten gleichen Alters am Fuß der Felsengebirge zusammen, und zwar, da das Land im Süden wie im Norden gleichmäßig ansteigt, unter dem 100° w. L. schon auf einem 500 m überall überschreitenden Niveau, das sich bis zum Aufkippen der Schichten am Fuß des eigentlichen Hochgebirges noch um etwa 1000 m, also auf 1500 m Höhe, steigert. Dieses Aufkippen erfolgt in den Staaten Montana, Wyoming und Colorado, und hier liegt also die Grenze

dieser »Great Plains« genannten Prärieregion, welche durch ihren scheinbar ebenen Charakter über das starke Ansteigen nach Westen hinwegtäuscht.

Und nun folgt, bis an die Küste des Stillen Ozeans heranreichend und sich dort erst mit rasehem Steilabfall senkend, ein mächtiges Hochland mit aufgesetzten Kämmen und Gipfeln, welche besonders bei dem östlichsten Steilaufstiege in den Rocky Mts., und hier wieder hauptsächlich in Colorado, in imposanter Höhe das Hochland beherrschen. Die als »Parks« und »Ranges« bezeichneten hauptsächlichsten Territorien führt HARSHBERGER S. 107 an.

Aber naturgemäß beginnt nun auch schon an der Westlehne dieser höchsten Kämme und Gipfel die Sammlung der Quellflüsse gegen den Stillen Ozean, und — weil die Küstenketten (Sierra Nevada u. a.) gegen diesen hin noch einmal eine mächtige Sperre bilden, so brechen die zu großen Strömen angesammelten Gewässer aus den westlich an die Rocky Mts. vorgelagerten inneren Hochflächen in wenigen Durchbrüchen heraus: an der Grenze der Staaten Washington und Oregon der mit dem Snake River vereinigte Columbia Fluß; an der Grenze von Californien und Arizona der Colorado, dessen nördlicher Quellarm, der Green River, sich im Gebiet der Uintah Mts. und in Wyoming sammelt, und der zwischen der Mohave-Wüste im NW. und der Gila-Wüste im SO. eingeschlossen nach Sonora übertritt und sich in den Golf von Californien ergießt. Nur ein Strom sammelt mit seinem Hauptarm auf der Westseite der südlichen Felsengebirge, mit einem kleineren auf der Ostseite, und bricht nach der Vereinigung beider südostwärts aus dem Gebirge, um in den Golf von Mexiko sich zu ergießen: der Rio Grande del Norte, dessen Quellarme in Colorado und Neu-Mexiko liegen.

So sind denn die inneren Hochflächen zwischen dem Felsengebirge und den Küstengebirgen an die beiden erstgenannten Ströme angeschlossen und werden als Columbia Plateau sowie Colorado Plateau (S. 108) charakterisiert; zwischen beiden liegt noch das abflußlose Becken des großen Salzsees von Utah mit der sich an ihn anlehnenden »Great Salt Lake Desert«. Die Schilderung der Küstenketten selbst, voranstehend die Sierra Nevada, bildet hier den Schluß (S. 109—111).

Die weitere Abgrenzung der durch die hohen Gebirgsketten vielfach durcheinander geworfenen und auf ihnen boreale Verbindungen erhaltenden Vegetationsregionen ist hiernach mit einem Blick auf die Karte verständlich: die Region der Rocky Mts. (mit den Black Hills, welche an der Grenze von Dakota gegen Wyoming unter 104° w. L. schon östlicher aufsteigen) zieht fast in der ganzen Länge der Prärieregion von Neu-Mexiko im Süden bis zum 60° n. Br. zum Anschluß an die Tundren in Alaska. Der pacifische Küstenstrich ist in drei Regionen gegliedert, über deren nördlichste, die Sitkaregion, schon oben (S. XXI) kurz berichtet ist; die mittlere ist die columbische Region mit den Durchbrüchen des Fraser R. und Columbia R. von den nördlichen Felsengebirgen her; die dritte ist die von Californien. Endlich wird die Hauptmasse der eingeschlossenen trocknen Hochflächen (Columbia- und Colorado Plateau) eingenommen von der Vegetationsregion des Großen Bassins mit

den Wüstensteppen von Oregon, Nevada und Mohave-Wüste Californiens. An diese schließen sich südwärts zwei andere Regionen, welche mit dem Großen Bassin, und den Prärien von Texas bis Dakota zusammen den Kernpunkt des oben besprochenen Sonorischen Florenreichs bilden würden: im SW. die Sonorische Wüstenregion der HARSHBERGERschen Karte, und im SO. dessen Chihuahuan Wüstenregion; diese beiden gehen weit nach Mexiko hinein und berühren sich demnach innig mit der nächsten (südlichen) Gebietsabteilung.

Die Prärienregion (S. 510—546) erhält zunächst eingehende floristische Schilderung, erläutert durch die Bilder der Bunch-Grasformation (S. 523), Tafel XII mit den Ansichten der Mesaregion und Salzsümpfe (*Artemisia, Euphorbia marginata*, S. 533), und der *Yucca angustifolia*-Steppe (S. 538). Anknüpfend an die im Abschnitt III besprochene Entwickelungsgeschichte in geologischen Zeiträumen geht HARSHBERGER zunächst auf die verschiedenen über die Entstehung der Prärien geäußerten Meinungen ein (S. 516). Ich huldige durchaus der persönlichen Anschauung des Verfassers, daß die Prärie in der Hauptsache sich in sich selbst als Grasland erhält, weil die herrschenden Pflanzen andere, ihnen feindliche Vegetationsformen fern halten; die Entwicklung des Landes war aber dereinst der Besiedlung mit Gräsern günstiger als jeder anderen.

Von den Gräsern beherrschen 33 Arten die Prärieformationen (S. 518), und Nebraska — Kansas — Dakota haben diese Arten sämtlich. (Hier wird oft auf die eingehenden floristischen Arbeiten von CLEMENTS und POUND zurückgegriffen: siehe Bibliography S. 64 oben; auch die Arbeiten von BESSEY, PORTER und COULTER, RYDBERG u. a. sind, als zu den »Central United States« gehörig in Sect. II, S. 56—66 der Bibliography zu suchen und ergänzen sich erst von den Rocky Mts. an durch Sect. IV, S. 71 und ff.) Diese genannten Staaten, zu denen noch Jowa hinzukommt, gelten daher als Zentrum der heutigen Prärienflora!

Die Distrikte derselben gliedern sich ganz natürlich so, daß ein Übergangsdistrikt mit den bewaldeten Prärien im Osten beginnt (S. 519—526), in dem aber schon in Illinois sich feuchte und trockene Prärieformation echt findet —, daß dann in dem Prärien- und Sandhügeldistrikt das richtige Zentrum dieser Formation zur Darstellung gelangt (S. 526—531), die sich anschließenden Sandhügel von Nebraska bis zu beiden Dakotas nordwärts und bis Kansas, Oklahoma und Texas südwärts, ja bis zum nordöstlichen Colorado (S. 531—533), und daß endlich der »Foothill District« den Schluß macht an der Umrandung des eigentlichen, kühn aufstrebenden Hochgebirges von Neu-Mexiko, Colorado und Dakota bis Montana, Assiniboia, Alberta und zur Nordgrenze in Athabasca (S. 533—546; es sei auf das Versehen hingewiesen, daß diese Seiten als Kopfinschrift den Titel »Sand Hill District« anstatt »Foothill« tragen). Dieser letzte Distrikt hat zum besonderen Charakter die Einmischung einer großen Zahl von Montanarten, welche hier ihre Grenze gegen Ost erreichen. Dies wird ermöglicht dadurch, daß die weiten Flächen des Tafellandes durch zahlreiche

Canyons gefurcht sind; auch gedeihen hier Bäume und Büsche nicht nur in den Schluchten, wo sie auch im Sandhügeldistrikt sich finden, sondern auf den Hügeln und Köpfen der Erhebungen selbst, was zu einer nicht unbedeutenden Veränderung der Formationsanordnung führt. Aber auch hier herrschen noch auf weite Flächen die Gräser der Prärien in neuen Facies, nämlich *Stipa comata* und *Agropyrum spicatum* (S. 536). Salzsümpfe mit vorherrschender *Distichlis spicata* sind überall eingestreut (S. 539). Über ihre östlicheren Hauptareale hinweg erreichen hier nicht ganz wenige Holzpflanzen noch äußerste Westgrenzen und zeichnen dadurch die nördlicheren Foothills vor den südlicheren aus (S. 543: *Ulmus americana*, *Quercus macrocarpa*, *Juniperus virginiana* u. a.).

Ein besonderes Interesse beansprucht naturgemäß die Vegetationsregion der Rocky Mountains (S. 546—566), an welche der isolierte Bezirk der Black Hills angegliedert ist (S. 566—567). Das Titelbild, Tafel I, bietet in Mt. Stephen eine prächtige Ansicht aus dem nördlichen Distrikt, welcher als der der Northern Dominion (Canada) bezeichnet wird. Aus dem südlichen, dem Park Mountaindistrikt, zeigt Tafel XIII die merkwürdigen Verhältnisse der Travertine-Ablagerungen mit Nadelwald im Hintergrunde. (Diese Kalkablagerungen zeichnen bestimmte Geiser aus; das Pflanzenleben erlischt erst in den heißen Quellen bei wenigen Graden unter dem Siedepunkt mit weißfädigen Bakterien, während die grünen Algen am üppigsten bei 40—52° C gedeihen; s. S. 559.)

Es ist bekannt, daß die Felsengebirge im Süden trotz ihrer bedeutenden Höhen, und dann auch wieder im Norden bei abnehmender Gipfelhöhe, weder ewigen Schnee noch Gletscher tragen, daß die Abhänge schuttüberdeckt sind. Da nun rechts und links von den Hauptketten baumlose Ebenen, im Innern des Gebirges die »Parks« genannten hochgelegenen Kessel mit Steppenflora sich finden, so greift die montane Steppenflora des sonorischen Entwicklungsgebietes hier bis zu bedeutenden Höhen ein; die niederen Gehänge der hohen Ketten sind von Steppen und Gebüsch bedeckt, erst weiter nach oben hin folgt Wald, und diese Waldflora gehört dem pacifischen Florenelement an, welches sich zwischen Kalifornien und dem Puget-Sunde ausgebreitet hat. Beim Aufhören des Waldes in noch größeren Höhen treffen wir auf eine alpine Flora von streng nordischem Charakter, welche voraussichtlich am Schluß der Glacialperiode hier ihre Sitze einnahm, und über dieser laufen die schneefreien Gipfel in Felswüsten aus. Dieses allgemeine Bild erhält nun seine besondere Ausprägung in den verschiedenen Territorien beider genannten Distrikte, deren Grenze an den Quellwassern des Saskatchewan und Milk R. (Nebenfluß des Missouri) auf der Ostseite, am Clarkes R. (Nebenfluß des Columbia R., 48° n. Br.) auf der Westseite gelegt wird (S. 546). Bezüglich der Liste von Bäumen und Sträuchern wird auf Abschn. III (S. 244—250) verwiesen.

Es mag bemerkt werden, daß trotz vieler neuerer Forschungen doch noch recht viel in Erforschung der Flora der Rocky Mts. zu tun bleibt, und daß es wenige so gründlich zusammengestellte Sammlungen dafür gibt, wie sie in den letzten Jahren FREDERIC E. CLEMENTS aus Colorado herausgab zur Kenntnis

der dortigen Formationen. Das äußert sich auch in einer gewissen dürftigen Behandlung namentlich des Northern Dominiondistrikts (S. 546—551) und in dem Vergleich der dort angeführten Literatur mit der des Ostens. Am besten ist die Waldflora in der Verbreitung ihrer einzelnen Baumarten auch hier bekannt geworden, mit *Pseudotsuga*, *Tsuga Pattoniana* (=Berg-Hemlock! siehe Anm. 2 auf S. 547) und besonders *Picea Engelmannii*, auch *Abies subalpina*, welche mit *Pinus albicaulis* besondere subalpine Bestände um 2000 m Höhe herum bildet (S. 549, Titelbild vom Mt. Stephen siehe oben S. XXI). In dieser Höhe beginnt auch die alpine Formation (Liste S. 192), deren Artbestand von den Selkirk Mts. in Liste angegeben wird, die aber hier der Ausbreitung mächtiger Gletscher ein Herabsteigen zu weit niederen Höhen vielerorts verdankt.

Die Waldgürtel im südlichen Park Mountaindistrikt, der sich mit einzelnen Ketten und vielen Gipfeln zwischen den Steppen der Great Basin-Region auflöst und verliert, sind nun wesentlich andere, und werden S. 552—556 als solche von *Pinus ponderosa*, *P. monticola*, *Abies subalpina*, *Pinus Murrayana*, *Larix occidentalis* mit *Picea Engelmannii*, *Parryana* (*pungens*) und anderen Nadelhölzern unterschieden, denen einige wenige Laubbaum-Assoziationen (*Populus tremuloides*, *Salix* und *Betula*) und Dickichte einiger *Quercus*-Arten mit *Cercocarpus* sich anschließen. Wiesen, Sümpfe und Seen erhalten neben den schon erwähnten Geisern ihre besondere Schilderung (S. 557—561), und dann folgt die Schilderung des offenen Graslandes unter dem Namen »Park Formation« (S. 561). Den Schluß bildet die Schilderung der alpinen Flora in Wiese, See, Sumpf, Staudenmatte und Gratschotter hauptsächlich nach den Ergebnissen in Colorado und im Yellowstone-Park (S. 562—566).

Die Region des Großen Beckens (»Great Basin-Region, S. 557—587), wie hier mit über das Columbia und Colorado Plateau hinaus erweitertem Begriff die inneren Wüstensteppen genannt werden, birgt mit z. T. wasserlosen Tälern, seinen tief eingeschnittenen Canyons, mit stufenförmig aufgebauten Hochterrassen, pflanzenleeren Höhen und Geröllfeldern, sowohl nach der systematischen als ökologischen Seite der Pflanzenwelt sehr viel interessantes! Wie die Rocky Mts.-Region inmitten durch die südliche Vegetationslinie der *Betula papyrifera* entzwei geschnitten wird, so geht durch das Große Becken die viel bedeutsamere Vegetationslinie der Gattung *Yucca* hindurch — die sich wegen der 4 atlantischen Species bis Georgia und Carolina ostwärts fortsetzt; die nach Mexiko einschneidende Südgrenze dieser Gattung zeigt, daß es sich hier um eine weitere »sonorische« Gattung handelt. Jedenfalls ist besonders schon durch die berühmte Expedition von FRÉMONT (Bibliogr. S. 72) im Jahr 1842 bekannt geworden, daß sich im allgemeinen die Gestrüppe der Sage brush-Formation von *Artemisia tridentata* südwärts bis an die Yuccagehölze erstrecken und durch sie abgelöst werden; die *Yucca* in Gesellschaft der Kakteen und hohen Zygophylleen-Sträucher erschien dem Reisenden in ihrer steifen und unsymmetrischen Gestalt noch widerwärtiger, als die Artemisien mit *Sarcobatus vermicularis* und *Ephedra* in den Salzsteppen. Wir sehen an diesem Beispiel, daß die zwischen dem Columbia-Fluß im Norden und dem Rio Grande del

Norte im SO sich erstreckende gesamte Region immerhin recht verschiedenartige Territorien in sich begreift, und es kann noch zweifelhaft erscheinen, wo die phytogeographisch praktischsten Grenzen zwischen den weiten Wüstensteppenregionen, in deren Mitte der Coloradofluß durchbricht, sich ziehen lassen.

Es kommt dazu, daß mannigfache Modifikationen im Wechsel der Jahreszeiten vorkommen, von denen vielleicht die Grenzlinien wichtiger Charakterarten abhängen. So ist im Hochtal des Rio Grande in Neu-Mexiko ein solcher Wechsel darin angezeigt, daß noch in der Breite von Santa Fé (35—36° N) der Himmel fast das ganze Jahr hindurch heiter ist, während im südlichen Teil von Neu-Mexiko im Juli eine bis zum Oktober dauernde Regenzeit einsetzt, wodurch die Entwicklung der Steppenpflanzen bis weit in den Herbst hinein sich verlängert und im August die Hochebenen vielfach in voller Blütenpracht angetroffen werden (WISLIZENUS' *Exped. 1846—47; Bibliogr. S. 87*).

*Die 4 Distrikte, in welche das »Große Becken« bei* HARSHBERGER *zerfällt,* sind der Oregondistrikt (den man vielleicht bei seiner inneren Lage zwischen Bitterroot- und Rocky-Mts. im Osten und den Cascades Range im Westen zweckmäßiger »Snake River-Distrikt« nennen könnte), der Nevadadistrikt mit den um den großen Salzsee gruppierten inneren Steppen (S. 570—574), dann folgt innerhalb des Areals der Gattung *Yucca* zunächst der Arizona-Neu-Mexikodistrikt, der sich ostwärts bis an die Ebenen des westlichen Texas und südwärts an die Steppenregion von Chihuahua erstreckt (S. 573—584), schließlich der Mohavedistrikt.

Im Oregon- (Snake R.) Distrikt zeichnet sich das Landschaftsbild durch Vorherrschen der Sagebrush-Formation von *Artemisia tridentata* aus, welche wahrscheinlich $^{9}/_{10}$ der Vegetation ausmacht — jene berüchtigte Vegetation, in der die in ein silbergraues Laub gekleideten Wermutbüsche wie ihre Gattungsgenossen im Orient den Charakter prägen (S. 569). Von großer Bedeutung ist des Fehlen sowohl südlicher als östlicher Charakterarten: *Larrea*, der Kreosotstrauch, fehlt, ebenso die Präriegräser *Buchloë dactyloides* und *Bouteloua oligostachya*. Feuchte Wiesen werden nach dem massigen Vorkommen von *Camassia esculenta* bezeichnet, auf alkalischem Boden in den Tälern wird das Wermutgesträuch vom »Greasewood«, *Sarcobatus vermiculatus*, abgelöst. — Alle diese Arten besiedeln auch den Nevadadistrikt, welcher außer Nevada und Utah noch Teile von Idaho in sich schließt; ausgedehnte Territorien desselben liegen bedeutend über der 1500 m Linie und die oft stark salzhaltigen Böden geben am meisten ausdauernden Compositen Raum, unter ihnen wiederum Artemisien. In 3350 m Höhe herrscht Charakterflora von 7 Gehölzen (S. 571). Von großem Interesse sind die alpinen Formationen mit z. T. weit verbreiteten arktisch-borealen Arten (*Carex*, *Luzula*, *Lloydia* usw. S. 573).

Südöstlich von dem berühmten Canyon der Colorado erstreckt sich der Distrikt von Arizona und Neu-Mexiko mit einer Menge von Bergketten und Gipfeln, welche durchaus Rocky Mts.-Flora besitzen; die Tafelländer oder Mesas verdanken niedrigen Mezquitebäumen, Dornsträuchern, *Yucca* und großen *Cereus* ihre Physiognomie, und an den niederen Berghängen erinnern harte

Eichen- und Piñon-Gürtel an die Mediterranflora mit Hartlaub. Hiernach wird eine Reihe von Formationen unterschieden, deren Bezeichnung, nicht nach den herrschenden Pflanzen sondern nach deren Standorten entlehnt, dem in der Landschaft nicht autoptisch Bewanderten zu verstehen nicht immer leicht fällt (S. 575—577). Dabei kommen merkwürdige Abweichungen der Standorte in bezug auf Höhe und Exposition vor, welche sich durch den überwiegenden Einfluß der feuchteren Talluft (z. B. am Rio Gila S. 578) erklären lassen. — Der Mohavedistrikt, dem in der »Botany of the Death Valley Expedition« durch COVILLE i. J. 1893 eine der ausgezeichnetsten Monographien aus dem amerikanischen Westen gewidmet ist, mit 21 Tafeln von Charakterpflanzen, erhält besonders eine Skizze vom *Larrea- Franseria*-Gesträuch (3 Arten dieser Compositengattung leben in der Mohave), sowie von den Hainen der *Pinus monophylla* mit *Juniperus utahensis* (S. 586). Auf keinem der hierher gehörigen Berggipfel gibt es eine klimatische obere Baumgrenze.

Die pacifische Abteilung vom mittleren Nordamerika. — Schon oben (S. XVII) wurde die geographische Skizze vom Aufbau des Landes westlich der Rocky Mts. einleitend gegeben und S. XXX fortgeführt mit dem Hinweise, daß sich nach Norden hin die besonderen floristischen Eigentümlichkeiten des Küstenstrichs, welche in der Kalifornischen Region gipfeln, langsam in der großen subarktischen Nadelholzregion verlieren. Dort herrschen Nadelhölzer — in der ganzen Gebirgsflora der pacifischen Abdachung herrschen Nadelhölzer und steigen mit abnehmender Breite zu immer höheren Gürteln an — es sind also zunächst besondere boreale Arten von *Picea*, *Abies*, *Tsuga* und *Larix*, zumal die Sitkafichte, an welche sich die pacifischen Waldformationen halten, denen sich dann in *Chamaecyparis*, *Pseudotsuga*, *Libocedrus*, schließlich in *Sequoia* Nadelholzgattungen mit beschränkterem Areal und bedeutungsvollen Endemismen südwärts gegen die Sierra Nevada anschließen; und schon nördlich vom 40° n. Br. beginnen dann auch eigenartige Steppen-Xerophytenformationen, bis auf der Halbinsel Californien der völlige Anschluß an die subtropischen Xerophytenformationen mit sonorischen Florenelementen erreicht ist. So steht hinsichtlich der Mannigfaltigkeit aller Vegetationsbedingungen Californien im Mittelpunkt des Interesses, wie schon ein Blick auf die bunten Grenzen der Vegetationsregionen dort lehrt. Im Norden die Eisströme der Gletscher, umsäumt von niederem Nadelwald an den Küsten: so zeigt es uns Tafel XIV vom Davidson Glacier (S. 587) zur Einleitung, während das mittlere Territorium mit dem Beispiel des Mt. Jefferson (Tafel XV zu S. 600; s. auch S. 111) uns in die prächtigen, von Schneegipfeln übertürmten Nadelwälder der Cascadenkette versetzt, auch mit dem charakteristischen Textbilde Figur 6 (S. 265) unter Bezug auf die dort mitgeteilte Liste der sehr zahlreichen Coniferen und wenigen begleitenden Laubhölzer. Dann führt uns Tafel III (S. 200) an der, der Waldflora südlich von der ehemaligen Eisbedeckung der Glazialperiode gewidmeten Stelle von Abschnitt III des Buches in die von der endemischen *Sequoia gigantea* besetzten großartigen Stellen der Sierra Nevada, deren Hochgipfel wiederum von anderen Arten des borealen Florenelementes

besetzt sind: *Pinus albicaulis* am Mt. Shasta, Textbild S. 284; und endlich zeigt das Textbild Fig. 29 (S. 610) uns in *Cupressus macrocarpa* eine endemische Nadelholzart von warm temperiertem Klimacharakter, welche den californischen Küstenstrich bewohnt. So gibt also schon die Betrachtung dieser Figuren uns Aufschluß über die Grundzüge der hier herrschenden Vegetationsbedingungen.

Verfolgen wir zunächst den Aufbau der im Norden ganz allein das Landschaftsbild beherrschenden Nadelwaldungen, so schildert der Verf. dieselben von der Sitkaregion S. 588—591, von der Columbiaregion (deren Charakter durch den dichtesten Wald in Nordamerika entsprechend mächtigem Regenfall und gemäßigtem Klima ihren besonderen Stempel erhält: S. 592) S. 594—599 und S. 601—602, endlich von der Californischen Region S. 605—608, wo im besonderen der »Redwood-Formation« von *Sequoia sempervirens* gedacht wird, dann S. 614—620 mit Schilderung der *Sequoia gigantea*-Genossenschaft und der subalpinen Waldungen, endlich auf S. 630—632. In jeder der Regionen haben außerdem Wiesen, Sümpfe und alpine Formationen mehr oder weniger lange Schilderungen erfahren, auch die des Seestrandes mit der Algenflora (S. 587, 593, 604, 609, 624).

Die Mannigfaltigkeit der Florenelemente und Formationen zwingt dazu, Californien in mehrere, recht scharf getrennte Distrikte einzuteilen, während die Zweiteilung der Columbischen Region in den Cascaden- und Puget Sund-Distrikt (S. 593) und den nach dem Mt. Olympus benannten Distrikt (S. 601) mit der Küstenkette in Oregon mehr einen geographischen Untergrund hat. In dem letzteren Distrikt herrschen *Pseudotsuga*, *Tsuga Mertensiana* und *Chamaecyparis nootkaënsis*, während *Pinus ponderosa* und *Tsuga Pattoniana* fehlen; der Wald ist einförmiger.

Die Californische Region besitzt zunächst in ihrem Coast Range-Distrikt (S. 603) einen Landstrich von eminentem Interesse, der, zwischen 42° n. Br. und $34\frac{1}{2}$° N gelegen, einen Bruch in seinen Bergketten nahe der San Francisco-Bai aufweist, keine boreal-alpinen Elemente in seiner einheitlich endemischen Flora von bedeutendem geologischen Alter besitzt, und von Süden her durch das sonorische Florenelement gerade so einen starken Einschlag erhält, wie sich die borealen Zuzügler von der Columbiaregion her in die Rotholz-(*Sequoia sempervirens*-)Formation einmischen. Die *Sequoia* reicht im Bezirk von Mendocino so weit, als die Nebel in den Monaten Juli—September die Regenfälle ersetzen; in ihrem Gefolge sind *Quercus densiflora* und *Castanopsis chrysophylla* (S. 603). Weiter landeinwärts erhalten die Berge ein mannigfaltiges Kleid von *Pseudotsuga* und *Quercus californica* (2 m im Stammdurchmesser!) u. a. Eichen, *Umbellularia*, *Torreya*; auch gibt es hier schon Dickichte von niederen Bäumen und Sträuchern in der Form der Chaparrals (S. 607), die auch z. T. hoch auf trockne Berghänge ansteigen (S. 608). Auch im südlicheren Bezirk von Santa Lucia kommt noch Rotholz vor, aber beschränkt auf isolierte Berghaine, während seltenere Nadelhölzer wie *Cupressus macrocarpa* und *Pinus Torreyana* hier auf Hügelketten nahe der Küste endemisch sind (S. 609).

Der Distrikt von San Joaquin (S. 611) beherrscht die innere Talsenkung von Californien zwischen den Küstenketten und der Sierra Nevada, die vom Sacramento und dem mit ihm sich vereinigenden San Joaquin-Fluß entwässert wird; ihre geologische Entwicklung ist in Abschnitt III S. 279 geschildert. Die bunte Karte zeigt diesen Distrikt in der Farbe der mittelnordamerikanischen Grassteppen und dürren Ebenen, welche hier voranstehen (S. 612), mit so mancherlei interessanten Arten von *Brodiaea*, *Gilia*, *Nemophila*, *Lupinus*. An den Flußufern wachsen Weiden mit *Platanus racemosa* und *Juglans californica*.

Nun folgt der mächtige Distrikt der Sierra Nevada mit Anschluß der Shastakette und der südlich vom Pitt River Gap gelegenen Berge (S. 613), ausgezeichnet durch die bestimmte Höhenstufen charakterisierenden Bestände der *Pinus ponderosa*, *Abies shastensis* (S. 614), über dieser letzteren die *Pinus albicaulis* bis zur Baumgrenze (S. 615, und Fig. 7 auf S. 284), dann in der Sierra selbst in niederer Höhenstufe Strauchbestände von *Fremontia*, *Quercus dumosa* und vielen anderen (S. 617), *Pinus ponderosa* 800—2000 m, *Sequoia gigantea* 1500—2400 m (S. 617), und alle diese werden dann durch andere Arten abgelöst, welche subalpine Waldgürtel bilden (S. 619). Die Arten der alpinen Formationen sind in Listen S. 254—259, im Vergleich mit den Rocky Mts. schon vorher S. 195—197 zusammengestellt.

Der letzte Distrikt ist der von San Bernardino (S. 621) mit den vorliegenden Inseln (S. 621—623). Das Festlandsterritorium liegt westlich der Colorado- und Mohave-Wüstensteppen, schließt niedere Berg- und Hügelketten in sich und grenzt an die sonorische Wüstenregion, deren Pflanzenwelt sich hier in breitem Zuge einmischen konnte. Auch dieser Distrikt hat demnach auf der Karte eine auszeichnende Signatur erhalten. Die Inseln, besonders die genauer durchforschte Insel Guadalupe, besitzen eine hübsche Anzahl von Endemismen (S. 623). In der Chaparralformation des Küstenterritoriums überwiegen Eichen (*Quercus dumosa*), neben diesen Büschen erheben sich offene Haine von anderen Eichen mit *Rhus laurina*. Auf den Bergen kommen von Bäumen noch drei Nadelhölzer vor; eine typische Bergform ist *Yucca Whipplei* (S. 625). Oft bilden Opuntien $^1/_3$—$^1/_2$ der Buschmasse, mit ihnen vergesellschaften sich *Eriogonum* und *Artemisia*. Sogar die nicht ganz wenigen Farne sind meist von xerophiler Struktur (S. 626). Nach dem Binnenlande zu (San Jacinto-Territorium, S. 627—633) verändert sich die Flora zumal in endemischen Typen (*Atriplex*, *Chorizanthe*, *Phacelia*, *Gilia*, *Astragalus*, *Calochortus*); die Arten scheinen hier also vielfach nur kleine Areale zu besitzen (S. 628).

### 3. Südliches Gebiet des Kontinents.

Hierunter faßt HARSHBERGER die heißen Xerophytenlandschaften von Mexiko, die Tropenküsten von Mexiko und die zentralamerikanischen Staaten bis Panama zusammen, in denen die Kordillerenkette ausläuft. Durch diese und die Hochflächen mit dem sonorischen Florenelement zeigt naturgemäß besonders Mexiko einen innigen Anschluß an die Vegetationsregionen der südwestlichen

Unionsstaaten, während die amerikanische Tropenflora, welche Zentralamerika und Westindien innig miteinander verbindet, nur an der Südspitze von Florida Anschluß an die atlantischen Golfstaaten der Union erhält. Es ist klar, daß die Behandlung des überreichen Stoffes hier eine noch mehr gedrängte werden mußte, um den Charakter des »Survey« aufrecht zu erhalten; da die gemäßigte und subtropische Zone von Canada und den Vereinigten Staaten am besten durchforscht ist und das Hauptinteresse des Verfassers auf sich lenkte, so mußten bei den Schilderungen der Tropenzone mancherlei Einzelheiten fortfallen (siehe Anm. auf S. 657).

A). **Mexikanische Subtropenzone und Gebirgsregionen** (Kap. V, S. 633 bis 656). Die geographische Übersicht in Abschn. II (S. 113—116) schildert den Aufbau des Landes und bespricht (S. 148—153) das Klima. Die floristische Literatur ist unter Sect. VII der Bibliographie mit derjenigen von Zentralamerika vereinigt (S. 82—87). — Der Isthmus von Tehuantepec schneidet von Mexiko einen kleinen östlichen, bzw. nordöstlich an das Kalkplateau der Halbinsel Yucatan angeschlossenen Teil ab, der seiner ganzen Lage nach zwischen der weiter östlich folgenden Tropenflora von Guatemala, Honduras, Nicaragua einerseits und der Golfflora, die an der Mündung des »Great Valley« (S. 112) sich ausbreitet, andererseits vermittelt. Diese Region wird daher als »Mexikanische Golfregion« bezeichnet, sie schließt sich über die Mündung des Rio Grande del Norte hinaus an die Prärien von Texas an, sie ist aber auch — was zu betonen wichtig ist — die erste floristische Region südlich des 60° n. Br, welche die atlantische Seite des Kontinents mit der pazifischen verbindet, allerdings auch nur auf die schmale Strecke dieses Isthmus. Westlich von ihm ist auch in Mexiko die Scheide zwischen pacifischer und Golfseite durchgeführt, und sie stützt sich naturgemäß auf die mächtigen Bergketten, welche westwärts in der Provinz Oajaca aufsteigend südlich von Puebla und der Stadt Mexiko ihre mächtigste Entfaltung mit vielen 2400 m Höhe überschreitenden Gipfeln erreichen.

So erhebt sich über den niedrig sandigen Küsten in Terrassen aufsteigend ein mächtiges Hochplateau, über welches sich schneebedeckte Vulkane bis zu 5580 m erheben (S. 113); die Umrandung der inneren Hochfläche fällt zwischen 18—20° n. Br. hauptsächlich nach Süden steil ab mit einer gegen den Stillen Ozean vorgelagerten Küstenkette, außerdem aber mit einer Wendung nach Norden in Puebla gegen die Golfküste der Provinz Vera Cruz, und von diesen imposantesten Ketten und Vulkankegeln verlaufen dann kettenförmige Sierras sowohl gegen den Rio Grande del Norte hin, als auch parallel zum Golf von Californien gegen die Provinz Sonora hin (Sierra Madre Occidental). Was die östliche Kette an Küstenland übrig läßt, gehört zu der obengenannten »Mexikanischen Golfregion«; was die westliche Kette übrig läßt, gehört einschließlich des weit aus dem Innern kommenden Rio Grande de Santiago-Tales in der Provinz Jalisco zu der Jalisco-Region, welche von HARSHBERGER auf die südliche Halbinsel Kalifornien übertretend abgegrenzt ist. Nordwestwärts schließt sich an diese dürre Region die Wüstensteppenregion von Sonora, und das lang-

gestreckte Gebiet der inneren Hochflächen wird als die Wüstensteppenregion von Chihuahua bezeichnet. Nun bleiben nur noch die Gebirgsregionen übrig die durch das eben genannte Tal des Rio Grande de Santiago an der Westseite in zwei Teile zerlegt als »Westliche Sierra Madre-Region« und als »Vereinigte Kordilleren-Region von Mexiko« bezeichnet werden, während an der Ostseite zwischen 21°—28° n. Br. in den Provinzen Nuevo Leon und Coahuila die Region der Östlichen Sierra Madre als ein schmaler Keil sich einschiebt. Die westlichen Ketten sind die höheren, halten auf weitgedehnte Strecken ununterbrochen die Höhe von 3000—3600 m.

*Hiernach ist das Klima der mexikanischen Territorien zu beurteilen*, besonders auch das des inneren Hochplateaus, dessen Situation mit dem, von Tibet vergleichbar ist. Es hat sich auch im Sprachgebrauch die Unterscheidung von vier Klimagürteln herausgebildet (S. 149), welche etwa in den Höhenstufen von 0—900 m, 1500—2100 m, 3000 m für die oberste Vegetationszone sich hält. Die Temperatur- und Regentafeln für die vier Jahreszeiten-Monate von einer Anzahl von Stationen (S. 150—151) lassen klare Einblicke in die durch die Höhe hervorgebrachten Unterschiede gewinnen; besonders interessant ist Chihuahua mit Jan.-Min. unter Null (Mittel 14° C.) und Juli-Max. von 35° C. im Gegensatz zu den Küstenstationen mit etwa 14° C. Jan.-Min. und 21°—24° C. Jan.-Mittel. — Noch wichtiger beinahe als die Temperatur erscheint der Wechsel der Luftfeuchtigkeit, deren relativen Betrag Chihuahua im Mai mit dem Minimum 26%, im September mit dem Maximum 47% ansetzt, während die tropischen Küstenstationen eine Schwankung von 65% bis 78% anzeigen. Das Klima der Stadt Mexiko selbst, welche sich nach den Tabellen als eine Station mit mittleren Extremen herausstellt, ist als eingehendes Beispiel für sich behandelt (S. 149—153).

Von den fünf Vegetationsregionen, in welche das mexikanische Subtropengebiet nach HARSHBERGERS Karte zerfällt, schließen sich naturgemäß die drei Gebirgsregionen der westlichen, der östlichen Sierra Madre und der Vereinigten Kordillerenkette im südlichen Mexiko an die Vegetationsverhältnisse der südlichen Rocky Mts., bez. der südlichen Sierra Nevada und San Jacinto Mts. an, während die beiden Wüstensteppenregionen von Sonora und Chihuahua das großartige Bild der westlich-nordamerikanischen Xerophytenflora vervollständigen, indem sie zumal von Vegetationsformen wie Opuntia, Cereus, Mamillaria, Echinocactus, Yucca, Larrea und den Dornsträuchern der Leguminosen die prächtigsten Typen aufweisen. *Gleichzeitig treten hier auch in den* an Grundwasser reicheren Rinnsalen xerophytische Palmen auf von eigenartig endemischem Charakter, wenn sie auch — wie in den atlantischen Südstaaten — gleichfalls den Sabaleen angehören. Diesen Elementen sind auch schon im Abschn. II ausführliche Besprechungen (*Yucceae*: S. 285, *Cacteae*: S. 296) und Abbildungen gewidmet, so Fig. 8 *Yucca Treculeana* (S. 286), Fig. 9 *Cereus pecten aboriginum* (S. 297), Fig. 19 *Dasylirion acrotrichum* (S. 335) und Fig. 20 *Beschorneria yuccoides* (S. 335), zu denen der Text S. 293—296 nachzulesen ist, während in dem die Formationen schildernden Abschn. IV noch die beiden

Landschaftsbilder Fig. 30 *Cephalocereus senilis* (S. 644) und Fig. 31 *Cereus geometrizans* (S. 648) für die ungeheuer formenreichen Kaktusgewächse dazu kommen.

Die Sonora-Wüstensteppenregion (S. 633—640) umfaßt die Landschaften am unteren Colorado und Gila R. (S. 633 Textzeile 4 von unten steht versehentlich »Rio Grande«), und geht südwärts sowohl auf den Hauptteil der langgestreckten Halbinsel von Nieder-Californien über, als auch in gleich langer Erstreckung an der gegenüber liegenden Festlandsküste bis zu der auf der Karte als Demarkationslinie benutzten Nordgrenze der Mangroven.

Sie zerfällt demgemäß in den nördlichen Yumandistrikt (S. 634), in den Sinaloadistrikt zwischen Sierra Madre und Golf von Kalifornien (636), und in den Distrikt von Nieder-Kalifornien einschließlich der Inseln (S. 638). Die Formationen gliedern sich in die der Wüstensteppe mit offenen Hainen und Gebüschen (Chaparral), in die der sandigen Wüsten, der eingeschnittenen Canyons, Dünen und Deltabildungen. In der Gilawüste des nördlichen Distrikts (112° bis 114° w. L.) ist schon durch EMORY i. J. 1848 die fast allgemeine Verbreitung des hohen, wie ein Koloß in die Landschaft ragenden *Cereus giganteus* bekannt geworden, den die Eingeborenen Pitahaya nennen; seine Stammhöhe beträgt 8—20 m, Durchmesser bis fast 2 m, Früchte eßbar. (Farbiges Landschaftsbild in WHEELERs Report 1878.) —

Die Chihuahua-Wüstensteppenregion (S. 643—648) zeigt den Buschtypus der Chaparralformation besonders reich entwickelt, welche diese Region mit den Prärien im südwestlichen Texas verbindet. Mimoseen und Caesalpinieen mit Pappeln, Celtis, Larrea, Fouquiera, auch *Juglans rupestris*, sind die Hauptbestandteile. Neben Yucca wird hier besonders *Agave heteracantha* auf steinigen Abhängen bedeutungsvoll. Die *Yucca-*, *Cacteae-*, *Compositae*-Arten von genereller Bedeutung werden in Listen aufgeführt (S. 646—647).

Die westliche Sierra Madre (S. 640—643) steht im Gegensatz zum mexikanischen Hochplateau durch das Zurücktreten sukkulenter Gewächsformen und das Vortreten eigener Kiefern-Eichen-Bergwälder in 2150—3000 m Erhebung; viele Täler haben eine Grasdecke mit Agave, Amaryllis und Hochstauden wie Helianthus, deren Bestand als Parkformation bezeichnet wird. Bis nach Arizona hinein erstreckt sich auf den Chiricahuabergen dieser mexikanische Florencharakter in einer Anzahl von Nadel- und Laubhölzern. — Wenig genaue Florenaufnahmen sind von der östlichen Sierra Madre zu uns gekommen (S. 649—650), für welche einige Skizzen aus der Provinz Nueva Leon südlich Monterey (25 $^1/_2$° n. Br.) eintreten; hier liegt an den regenreichen Hängen die Nordgrenze der *Pinus Montezumae*, und dichte Wälder von *Carya myristiciformis* schließen jede andere Baumart aus.

Die Vereinigte Kordillerenregion (S. 650—656) hat ihren pflanzengeographisch interessanten Zug durch die Einschaltung der Kette berühmter vulkanischer Piks erhalten, deren Verbindungslinie senkrecht die Strichrichtung der beiden Sierras durchsetzt und demnach den Golf mit der Pacifischen Abdachung durch einen Querriegel verbindet. Die Täler liegen in bedeutender Höhe (Toluca als das höchste 2600 m), das von der Stadt Mexiko hat durch die Kultur vieler Jahrhunderte seine ursprüngliche Vegetation eingebüßt. —

Über 2450 m Höhe beginnen Bergwälder bis 3350 m: *Pinus leiophylla* - *Montezumae* → *Alnus acuminata* → *Abies religiosa* als subalpiner Gürtel reichem Strauch- und Staudenwuchs. Auf den Wiesen wächst eine vermu wilde Form von *Solanum tuberosum* (S. 652). Die Schilderung schließt mit dem Formationsaufbau am Orizaba (S. 652—654), Popocatepetl, Ixtaccih Toluca und Colima [1]. Da der Pic von Orizaba aus der tropischen Niede von Vera Cruz bis zu der Linie des ewigen Schnees bei 4570 m gleichm aufsteigt und sich noch im Bereich der boreal-alpinen Florenelemente befi so zeigt vielleicht kein anderer Hochgipfel so wie dieser die Reihenfolge klimatisch sich ablösenden Formationen mit ganz verschiedenem regio Charakter. So schilderte es schon LIEBMANN der Versammlung skandinavi Naturforscher in Stockholm 1842, aus der seine topographischen Bilder i Botan. Zeitung 1844 übergegangen sind (Bibliogr. p. 84). In 900—1800 der Übergangsgürtel von Eichen mit sechs darunter wachsenden Chamaed Palmen, die pflanzenreichste Höhenstufe Mexikos mit 8—9 Monate daue Regenzeit und etwa 21° C. Mitteltemperatur; dann erst beginnt 1800—23 hoch die Eichenwaldformation mit Yucca, Clethra, Cornus, Crataegus, *leiophylla*: von dieser Höhe an zeigt demnach der Pik einen sich an die S Nevada und andere westamerikanische Gebirge anschließenden Florenchara

B). **Tropenzone von Mexiko und Zentralamerika** (Kap. VI, S. 65 672). Mit den beiden lang hingestreckten Zungen der Vegetationsregion Jalisco am Stillen Ozean und der Mexikanischen Golfregion, deren Lage s oben besprochen wurde (S. XL), umklammert der tropische Bestandteil amerikanischen Kontinentalflora die Gebirgsgürtel von Mexiko samt ihren i eingeschlossenen Hochplateaus mit Wüstensteppen, und er nimmt dann Rest des Landes bis Panama für sich ein, obwohl es — wie die zahlreic gesetzten roten Punkte in diesen letzten Regionen zeigen — nicht an I gipfeln fehlt, auf denen sich noch der boreal-subtropische Florencharakte den Gebirgsketten bis über den 10° n. Br. hinaus fortsetzt.

So knüpft denn die geographische Skizze des Landes (S. 116—121) an Fortsetzung der Kordilleren an, in der mehrere Gipfel nahe an 4000 m, einer sogar 4210 m Höhe erreichen, und bespricht die Gliederung der einz Republiken Guatemala, Honduras, San Salvador, Nicaragua, welche zu zentralamerikanischen Provinz, der Guatemalaregion, zusammeng werden, auf welche dann schließlich Costa Rica und Panama als Bestan der südamerikanischen Florenprovinz mit dem Namen der Costa F region folgen (S. 119).

Schon in der geographischen Übersicht wird zur Erklärung des Fl charakters der Gegenwart, wie er sich in der regionalen Einteilung ausdr soll, auf die Entwicklungsgeschichte des Landes, zumal auf die Bildun Karaibischen Meeres in verschiedenen Perioden hingewiesen. Wie Fig. 2 (S zeigt, brach zum Schluß der Kreide- und Beginn der Tertiärperiode eine L

1) Siehe KARSTEN u. SCHENCK, Vegetationsbilder V. Reihe, 8. Taf. 46—51.

*bezeichnet mit den Ziffern 5—5, in den schmalen heutigen Landstreifen ein,* welche das vorher breit über die Antillen mit Mexiko verbundene Südamerika isolierte. Fig. 3 (S. 179) zeigt das Karaibische Meer abgesperrt durch die mit 3—3 bezeichnete Landbrücke im späteren Miocän, Fig. 4 (S. 206) das der Gegenwart am nächsten kommende Stadium; vergleiche dazu HARSHBERGERS Text S. 119, und die Idee der sich im spitzen Winkel kreuzenden Richtungen der südamerikanischen Anden und der nordamerikanischen Kordilleren (Rocky Mts.), deren Verlängerung südwärts in den tiefen Ozean westlich von Südamerika fallen würde, S. 120.

Das Klima von Zentralamerika ist für die drei Staaten Guatemala (S. 153), Nicaragua (S. 154), Costa Rica (S. 157) und Panama (S. 159) in genügender Ausführlichkeit mitgeteilt; besonders wertvoll erscheint (S. 154) der Vergleich von sechs Stationen in Guatemala zwischen Küste und 2350 m Höhe mit den Monatsmitteln in Celsiusgraden; das oberste Bergklima mit $10\frac{1}{2}^{0}$ C. Januar- und $17^{0}$ C. Mai- und Junimittel ist ein wundervoll gemäßigtes.

An klimatische Fragen knüpft auch HARSHBERGER (S. 656) seine speziellen floristischen Schilderungen an, welche die schon vorhin genannten Regionen vom westlichen Mexiko an bis zur Region von Costa Rica der Reihe nach schildern. Die tropische Waldformation steht hier im Vordergrund des Interesses (S. 661, 664, 666, 669); Fig. 32 (S. 663) zeigt einen Palmenwald. Die Guatemalaregion (S. 663) wird als ein eigener Abschnitt, als ein Zwischenglied zwischen der mexikanischen und der sich an Südamerika anschließenden costaricanischen bezeichnet, weil die mexikanischen Elemente der Wüstensteppen hier fehlen, während manche südamerikanische Tropenelemente das südliche Mexiko nicht mehr erreichen; endlich ist die Bergflora von Mexiko und Zentralamerika erheblich verschieden.

Diese allgemeinen Sätze erhalten ihre besondere Begründung in den Chaparralformationen der Golfregion von Mexiko, deren Facies noch vielerorts von *Parkinsonia texana*, *Acacia Berlandieri* u. a. A., bestimmt wird (S. 659). Auch der strauchige Chaparral enthält in *Prosopis juliflora*, *Acacia farnesiana*, *Diospyros texana* u. a. A. Typen aus den weiter nördlich sich anschließenden Territorien (S. 660). Natürlich verschwindet diese kräftige Formation nicht plötzlich, und — ohne genaue Angabe der Einzelarten — tritt sie auch neben Kiefern- und Eichenbeständen im südlichen mittleren Guatemala und San Salvador in Form von Dornsträuchern mit Opuntia-, Mamillaria- und Cereus-Arten wieder auf (S. 665—666). Auf den südlichen Vulkanen herrschen immergrüne Eichen von 2100—2700 m Höhe, über ihnen Pineten, neben ihnen das bekannte mexikanische *Cheirostemon* (= *Chiranthodendron*) *platanoides*, »Handbaum«, eine mit Fremontia verwandte Sterculiacee, und in der genannten Höhe verschwinden die am höchsten ansteigenden Elemente des Tropenwaldes. — Da die Schilderung der tropischen Gebiete Nordamerikas ihr wesentliches Interesse darin in unserem »Survey« zu suchen hat, daß sie das Auslaufen der spezifischen subtropisch-amerikanischen Florenelemente aus höheren Breiten zu verfolgen gestattet, so sei auf S. 665 verwiesen, wo der ausgedehnten Bestände

von *Pinus caribaea* neben *Quercus virginiana* in der Kiefern-Bergrücken-formation von Guatemala gedacht wird; ferner auf die Zusammensetzung der Berggipfel-Formationen am Irazu und Volcan de Barba mit Gaultheria, Gunnera und Calceolaria neben Senecio und Hieracium, endlich auf S. 669, wo das Aufhören aller Arten von Yucca, Nolina, Dasylirion, Beschorneria, und ihr schwacher Ersatz durch einige Fourcroya- und Agave-Arten festgestellt wird. Dagegen treten ganz neue tropische Formationen auf, außer dem immergrünen Regenwalde und den schon erwähnten Palmenhainen die Mangroveformation an der atlantischen und pazifischen Küste (S. 663) und Savannen (S. 667, 671).

Die Savannen hat schon M. WAGNER auf seinen Forschungsreisen 1857—59 als ein besonderes Merkmal des tropischen Nordamerikas zwischen Panama und der mexikanischen Provinz Chiapas festgestellt (Bonplandia 1860, S. 379), ausgerüstet mit Savannenwäldern aus lichtfreundlichen Bäumen und Sträuchern, die eine langanhaltende Dürre ertragen, mit *Duranta Plumieri*, *Davilla lucida* und *Curatella americana*. Denn an der pacifischen Seite des tropischen Nordamerikas herrscht vom Dezember bis April Trockenheit, während die Karibische Seite vom Nordost-Passat andauernde Regen erhält.

## 4. Westindisches Gebiet der amerikanischen Tropenzone.

Klar abgerundet in seiner insularen Natur liegt der letzte Teil des im »Survey« behandelten Länder- und Inselreiches mit einer einzigen »Vegetationsprovinz« vor uns in drei unterschiedenen Regionen: die Antillenregion umschließt Cuba, Jamaica, Santo Domingo, Puerto Rico und die Jungferninseln; die kleinen Antillen sind ausgeschlossen. Jede der genannten Inseln wird als besonderer Distrikt nach ihrem Formationscharakter beschrieben (S. 673—688), die Jungferninseln im engeren Anschluß an Puerto Rico. Die Insel Jamaica hat die drei schönen Ansichten von Tropenformationen geliefert: Taf. XVI (S. 672) zeigt die üppigen Bestände an einem Flußstrande, Taf. XVII (S. 677) die bewaldeten Abhänge in einem Tal, Taf. XVIII (S. 682) endlich den montanen Baumfarnwald von *Cyathea arborea*.

Die Bahamaregion zerfällt in einen insularen Bezirk (S. 689—695), und in den kontinentalen Anteil, den die Südspitze von Florida, abgetrennt von der nördlich angrenzenden Atlantischen- und Golf-Küstenregion, zu diesem tropischen Bestandteile liefert (S. 695—700). Schon dieser eine wichtige Anteil, den die atlantischen Staaten an der amerikanischen Tropenflora nehmen, muß — so klein an Areal im Vergleich mit anderen Vegetationsregionen er ist — Veranlassung geben, die Gliederung von Westindien und die Auseinandersetzung der Beziehungen zu den subtropischen Formationen der »*Everglades*«, der Grenze der Sumpfcypressenwälder (*Taxodium*), die »*Pine Barrens*« von *Pinus caribaea*, die von Palmen (*Pseudophoenix*) durchsetzten »*Hammocks*« aneinander zu knüpfen — lauter Formationen, für deren deutliche Bezeichnung der kurzgefaßte englische Ausdruck jedenfalls der beste ist.

Die Region der Bermudainseln weit nördlich im Ozean, doch im Bereich des *Golfstromes gelegen, schließt die Aufzählung der einzelnen Territorien* (S. 701—704).

Der Vollständigkeit wegen ist noch nachzutragen, daß dieses letzte Gebiet gleichfalls seine eigene vollständige Bibliographie erhalten hat (Abschn. I, S. 87—92), daß die geographische Übersicht im Abschn. II (121—130) von den einzelnen Inseln ein Bild entwirft, welches für das Verständnis der regionalen Anordnung nicht zu entbehren ist, und daß dasselbe auf S. 161—165 durch eine gedrängte klimatische Übersicht — besonders für Jamaica wichtig durch Bezug auf Bergeshöhen — vervollständigt ist.

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## Die Florenelemente und ihre Ausbreitung in Nordamerika.

Von nicht geringem Interesse sind Vergleiche von Artenzahlen in weiten Länderräumen, um die Besiedlung der Erde darnach zu beurteilen. In dem Kapitel über die Statistik der nordamerikanischen Flora (S. 166—169) hat HARSHBERGER Materialien gebracht, welche ein recht helles Licht darauf werfen. Um sie hier im Auszuge zu besprechen, teile ich Nordamerika an der Nordgrenze von Mexiko in zwei Hälften. Die nördliche Hälfte kann man summarisch in ihrem Pflanzenreichtum abschätzen nach folgenden Zahlen: Flora von Canada (J. MACOUN) 3209 Arten; Flora der südöstlichen Vereinigten Staaten einschl. Mississippi und Texas (J. K. SMALL) 6364 Arten: endemische Arten der Rocky Mts. 659 Arten; westliches Nordamerika südlich von British Columbia (geschätzt nach mehreren S. 168 angegebenen Floren) an 3000 unter den vorigen nicht schon mitgezählten Arten: ergibt eine Zahl von mehr als *13000 Arten bis zur sonorischen Vegetationsregion. Die Schätzung ist natur*gemäß roh, sie zeigt aber, daß der Pflanzenreichtum in diesen wundervoll vielgestaltigen Gebieten nicht so groß ist, als man nach ihrer gegenwärtigen Durchforschung hätte erwarten können. Ich führe zum Vergleich NYMANS Conspectus (1882) für Europa mit 9395 Arten und 2014 Unterarten an, besonders aber, daß die Flora des Orients viel reicher ist als die ihr entsprechenden Gebiete Nordamerikas. In BOISSIERS »Flora orientalis« bilden (ohne die Nachträge) *die zehn artenreichsten Familien allein schon einen Komplex von 7200 Arten*; auch ist der Anteil endemischer Elemente im Orient besonders groß, große Gattungen wie Astragalus (760 Arten, davon 694 endemisch), Cousinia, Centaurea sind doch zahlreicher als die nordamerikanischen Aster und Solidago.

Mexiko und Zentralamerika besitzen nach HEMSLEYS Katalog, der nun auch schon wieder zahlreiche Nachträge erfahren hat, 11626 Arten, von denen 8193 endemisch sind; der Artreichtum ist also hier verhältnismäßig größer. Dazu kommt schließlich noch der westindische Anteil an der Tropenflora, für den HARSHBERGER die Zahlen einzelner Inseln mitteilt. Vielleicht kann man demnach den ganzen im »Survey« zusammengefaßten Florenreichtum auf eine Gesamtzahl von 30000 Arten schätzen.

Aus welchen Hauptelementen nun diese Kinder nordamerikanischer Flora sich zusammensetzen und wie sie ihre heutigen Plätze nach Annahmen aus der geologischen Landesentwicklung erreicht haben, wie sich Relikt-Endemismen an diesen, jugendliche Art-Endemismen an anderen Plätzen verstehen lassen, das alles wird von HARSHBERGER in dem sehr ansprechend geschriebenen Abschnitt III (S. 170—311) auseinander gesetzt, dem noch ein Kapitel über die verwandtschaftlichen Beziehungen der nordamerikanischen Flora zu anderen Ländern der boreal-kalten, gemäßigten und subtropischen Zone, zu der tropisch-südamerikanischen und chilenisch-andinen Flora (S. 311—341) angehängt ist. In diesem 4. Kapitel sind 12 Figuren als Beispiele vielseitiger System- und Florenelemente Nordamerikas aus den »Natürlichen Pflanzenfamilien« beigegeben, während alle anderen im »Survey« sich auf den Tafeln oder im Text findenden Illustrationen aus Originalen bestehen und großenteils nach Photographien im Folioformat hergestellt worden sind. —

Das Studium der Textfiguren 1—4 zum 1. bis 3. Kapitel von Abschn. III wird auf rasche Weise in die Florengeschichte Nordamerikas einführen; natürlich ist dabei zu berücksichtigen, daß die den Florenelementen gegebenen Signaturen in ihrer Allgemeinheit und geographischen Umgrenzung für die früheren Erdperioden theoretischen Anschauungen mit paläontologischem Untergrunde entsprungen sind, daß sie erst für das Postglazial den vollen Boden der Tatsachen gewinnen können, und daß daher nach dieser Richtung hin erst die Fig. 3 (S. 179) und besonders Fig. 4 (S. 206), deren eingesetzte Signaturen sich auf die Kenntnis der heutigen Florenverbreitung stützen, aus dem theoretischen Rahmen in denjenigen vollwichtiger Erfahrung herübertreten.

Die untere Kreideperiode zeigt — gestützt auf paläontologische Funde — den gleichen Generaltypus von Coniferenvegetation über den Kontinent bis in tropische Breiten (*S. 170, Fig. 1*). *Nun aber beginnt durch ozeanische* Verbindung vom mexikanischen Golf längs durch den Kontinent, etwa entlang den heutigen Kordilleren, bis zum heutigen Eismeer eine Trennung des atlantischen und pacifischen Florenelementes (Signatur 1 und 2, in Fig. 2 auf S. 172), während zwischen Zentralamerika, den Antillen und Südamerika noch wechselnde Landverbindungen herrschen, und zwar zu einer Periode, in welcher nachgewiesenermaßen überall in den borealen Florenreichen eine außerordentlich *starke Entwickelung neuer Formen Platz gegriffen hatte.*

Der Ursprung dieser vielen, plötzlich auftretenden neuen Formen erscheint auch für Nordamerika dunkel; aber sie sind da, zahlreiche Dikotyledonen (S. 171—173, Liste S. 177). HARSHBERGER glaubt, diese starke Vermehrung der Typen nach dem Evolutionsprinzip von H. DE VRIES sich leichter erklären zu können. Es folgt die starke Weiterentwicklung wichtiger Baumtypen aus Coniferen und Dikotylen im Eocän und Miocän ganz analog dem süd- und mitteleuropäischen, ja dem *arktischen Tertiär* (*S. 174—176*), die Bildung jener wundervollen Flora, die für Europa durch SAPORTA und HEER so prächtig geschildert ist, und welche in Europa so wenige, in Nordamerika — zumal auf der atlantischen Seite — so viele ausgezeichnete Typen zurückgelassen hat.

Die Differenzierung der Flora nimmt zu, die Tropenflora der Antillen wird selbständiger, der Zusammenhang zwischen Nord- und Südamerika südlich von 10° N geht auf und nieder (Fig. 3, S. 179), der Unterschied zwischen atlantischer und pacifischer Flora hebt sich stärker heraus (S. 178).

Aus den präglazialen Perioden leitet HARSHBERGER die Standorte mancher Arten mit jetzt beschränktem Vorkommen ab, die während der langen Eiszeitperioden unter vielfacher Veränderung ihrer natürlichen Standorte, welche durch Denudation aus Tafelländern zu isolierten Bergspitzen werden konnten, oder die durch zwischentretende Eiszeitgletscher aus lückenlosem Zusammenhange zerrissen und zersägt werden konnten, sich unverändert am gleichen Platz erhalten haben. — Ein Beispiel der ersteren Art ist *Hudsonia montana* auf dem Table rock, N. C. (S. 178, 203), eine isolierte Cistacee in Verwandtschaft mit zwei anderen bis nach Canada verbreiteten Arten, *H. ericoides* L. und *H. tomentosa* Nutt.; die letzteren würden dann also weiter verbreitete oder jüngere Arten desselben Gattungstypus sein. Ein Beispiel der zweiten Art ist in dem heutigen Areal der berühmten *Sequoia gigantea* gegeben (S. 199—200), welches Lücken zwischen den nördlichen und südlichen Standorten genau in den Erosionsfurchen der Eiszeitgletscher zeigt, die zwischen Mt. Lyell im N. und Mt. Whitney im S. in den Tälern vom San Joaquin und Kings R. westwärts heruntergingen, und entsprechende Lücken zwischen den Sequoia-Wäldern von Mariposa und Calaveras.

So, wie hier gezeigt, wird also in den jüngeren Perioden die heutige Verbreitung der Arten an die alten geologischen Entwickelungszeiten anzulehnen versucht, Listen solcher Arten, die als Relikt-Endemismen gelten können, werden mitgeteilt, dazu die der pleistocänen Flora (S. 185—187).

Damit wird der Wirkung der Eiszeitperioden, der Ausdehnung des früheren Landeises von seinem Labrador-, Keewatin- und Kordillerenzentrum (S. 182) nach Süden und seiner verschiedenen Demarkationslinien mit Interglazialzeiten (S. 183) Rechnung getragen und die Glazialflora selbst in ihren Charakterzügen geschildert (S. 187—191, 197). Von ganz besonderem Interesse ist dann natürlich die Aufspürung der Glazialrelikte zunächst als unveränderter Arten in Hochmooren oder auf Berggipfeln, dann aber auch in den eigenen endemischen Formen der Gebirge, welche voraussichtlich während oder nach den Eiszeitperioden entstanden sind und von denen ein — jetzt nicht mehr genau kenntlicher — Teil beim Rückzuge des Eises nordwärts mit abgeflossen ist.

Hier ist es nun am Platze, die entwickelungsgeschichtlichen Fragen und das sich aus ihnen ergebende Gerippe der Flora wiederum mit der im Abschn. IV enthaltenen breiteren Formationsschilderung vereinigt zu denken, weshalb ich die wichtigsten Kapitel des letzten Abschnitts hier in Seitenzahlen mit angebe.

Es steckt die arktische Flora als herrschende Tundraformation in den Schilderungen von Kap. 1 (S. 346—350) und in den subarktischen Mooren (S. 353—355, 358—360). Mit abnehmender geographischer Breite stellen sich die arktischen Glazialrelikte auf immer größere Höhe ein, welche in Canada

und den Neu England-Staaten noch an vielen zerstreuten Punkten erreicht wird, aber in den Alleghanies nicht mehr, da sie nicht mehr hoch genug waren, um irgend einen lokalen Gletscher zu erzeugen (S. 181); um so mehr natürlich im Westen. Interessante Vergleiche lassen sich zwischen Nordamerika auf der atlantischen Seite und N.-Europa ziehen hinsichtlich der Zerstreuung der Relikte. *Pedicularis sudetica*, die ihren Namen von dem einzigen Gebirgs-Reliktenstandorte südlich vom Samojedenlande hat, ist im arktischen Canada gemein, geht aber nicht in die Gebirge, wo hingegen *Diapensia lapponica* gerade mit zu den ausgezeichnetsten Relikten auf den den Sudeten entsprechenden Bergeshöhen gehört (Taf. II, S. 188). *Cornus canadensis* ist die amerikanische repräsentative Art für *C. suecica*, diese letztere ist im Tundragebiet von Labrador bis Alaska verbreitet, geht aber nicht weit nach Süden, während *C. canadensis* (Taf. II unten) einer der am weitesten verbreiteten Charaktertypen von Canada südwärts in die Bergregion hinein ist, bis nach Indiana und Minnesota. Sehr verbreitet in diesen Landschaften sind auch *Rubus chamaemorus*, *Empetrum*, *Ledum*, *Chamaedaphne* und *Andromeda*, *Linnaea*, — und als nordamerikanische Typen *Clintonia borealis*, *Kalmia glauca*, *Chiogenes*.

So finden sich weiterhin die Standorte und Formationen der Glazialrelikte im atlantischen Nordamerika in den Bezirken Neu-Braunschweig und Neu-England in den baumlosen »*Dry barrens*« (S. 366) und Sümpfen, in den Sphagnum-Mooren (S. 367—368), zahlreich auf dem Mt. Katahdin (S. 371—373), auf dem Mt. Washington (S. 375—377), auf Mt. Mansfield in Vermont (S. 378), auch auf der Insel Mt. Desert country (S. 371), an den Glazialseen von Quebec (S. 391 bis 392), in den Mooren von Minnesota (S. 401—2), dann höher steigend in den schon oft erwähnten Adirondack Mts. (Liste S. 406—407), nicht mehr in den Sümpfen der nördlichen Pine Barren-Strandregion (S. 425), wohl aber in den Sphagnum-Mooren des nördlichen Appalachendistrikts (S. 481—2, *Ledum*! *Chamaedaphne*! *Scheuchzeria*!); *Lycopodium Selago* findet sich mit *Potentilla tridentata*, *Alnus viridis* und zahlreichen amerikanischen Typen noch auf den baumlosen Gipfeln des südlichen Appalachendistrikts (Roan Mt., S. 496).

Während es hier im Osten an einer voll entwickelten alpinen Flora überhaupt fehlt, ist dieselbe um so kräftiger auf den Bergsystemen des Westens entwickelt, mit weit südwärts vordringenden Arealen heutiger Arktis-Arten und, wie schon oben hervorgehoben, mit stark ausgeprägtem eigenen Endemismus. Wegen der ganz besonderen Klimalage und den sehr verschiedenen Bodenverhältnissen hält HARSHBERGER hier die Bedingungen für die Species-Differenzierung für besonders günstig (S. 181), und widmet nun im entwicklungsgeschichtlichen Teile, Kap. 2, einen eigenen Passus der Flora in den Rocky Mts. und in der Sierra Nevada (S. 191—197), der sich besonders durch zwei Florenlisten von Dikotyledonen-Hochgebirgsarten auszeichnet. Es mag erwähnt werden, daß der i. J. 1848 nach Illinois ausgewanderte deutsche Mediziner und Florist FR. BRENDEL i. J. 1888, angeregt durch eine Liste der Rocky Mts.-Alpenpflanzen in ENGLERs »Versuch einer Entwicklungsgeschichte«, eine Liste mit Nachträgen und Zusätzen mancherlei Art ausgearbeitet hatte,

an deren endgültiger Herausgabe ihn Krankheit und Tod hinderten. Diese Fragmente konnten vom Verf. mit benutzt werden. Von Bedeutung ist aber die Liste hauptsächlich durch den Hinweis auf die verwandtschaftlichen Beziehungen der zahlreichen endemischen Gebirgsformen mit weiter verbreiteten nordischen Arten (S. 191): es entsteht naturgemäß die Frage, ob diese endemischen Formen sich als neue Arten seit ihrer Wanderung entlang den Rocky Mts. entwickelt haben, oder ob sie die Relikte einer früheren arktisch-alpinen Vegetation darstellen? Das Resultat (S. 194) ist, daß ein kleiner Teil dieser reichen Hochgebirgsflora von früheren Perioden her entstanden sein und hier überdauert haben mag, daß aber in der größeren Zahl der Fälle die Verwandtschaft der alpinen Arten mit den nordischen Tundrapflanzen die Gemeinschaft mit deren Ursprung, also mit einer Umbildung des alten Typus in einen endemischen Lokaltypus, anzeigen muß. Und diese Meinung wird sehr schön durch die zweite Liste (Sierra Nevada, S. 195—197) bestätigt, in der das endemische Element sich ebenso vermehrt zeigt, wie die Lage der Sierra südlicher und von den Zuzügen der arktischen Glazialpflanzen entfernter ist. So sind auch die durch Signaturen ausgedrückten Gemeinsamkeiten mit Europa und dem arktischen Nordamerika entsprechend geringfügiger an Zahl, während anderseits das endemisch-nordamerikanische Element sich in Gattungen wie *Lupinus*, *Claytonia*, *Calandrinia* und *Spiraea* ausdrückt (S. 195).

Die genannten wertvollen Listen, in denen allerdings die Monokotylen fehlen, finden nun ihre ausgiebige Ergänzung im Abschn. IV Kap. 3 § 2 (S. 546—567) für die Rocky Mts., und in Kap. 4 § 3 (S. 610—621) für die Sierra Nevada. Was die arktisch-alpinen Florengenossenschaften selbst anbetrifft, so finden wir solche bereits in den Moosmooren der subalpinen Coniferenregion (S. 549) mit *Empetrum*, *Viola labradorica* u. a.; *Dryas Drummondii* zeigt hier die jung-endemische Form neben der zirkumpolaren *D. octopetala*, *Alnus sinuata* ersetzt *A. viridis* (S. 550), eine Liste S. 550—551 nennt die alpinen Arten der Selkirk Mts. Im südlichen Park Mountain-Distrikt sind hierher gehörige Espen- und Weidenformationen mit *Potentilla fruticosa* (S. 557), Sumpfwiesen mit *Betula pumila* und *Menyanthes*, auf den Felshügeln wächst *Arctostaphylus Uva ursi* neben *Juniperus alpina* und *Eriogonum* (S. 562—563), und die Schilderung der alpinen Formationen aus Colorado (S. 562—564) und aus dem Yellowstone Park (S. 565—566) ergibt eine höchst interessante Übersicht der Arten, *Luzula spicata* und *Dryas*, *Pedicularis groenlandica* und *Saxifraga nivalis* bis zur *Douglasia montana* mit *Pentstemon Menziesii* in weit verbreiteten boreal-alpinen, in enger verbreiteten arktisch-glazialen und endlich in eng verbreiteten Rocky Mts.-Arealformen. Und dafür ladet dann zum Vergleich die Liste der Hochgebirgsarten von dem Mt. Shasta ein (S. 616), während für die Sierra Nevada der in Abschn. III stehenden großen Liste nur kleinere Schilderungen zugefügt werden, so besonders die der feuchten Wiesenformation (S. 618—620) mit *Pedicularis groenlandica* neben *Claytonia* und *Dodecatheon*. Die Gattung *Pedicularis* spielt im Appalachensystem gar keine Rolle, wohl aber hier.

Auch weiter nach Süden tritt auf der Höhe der Gebirge das boreale Element noch auf, aber selten und verdünnt durch die immer mehr überhandnehmenden endemischen montanen Arten. Der San Bernardino-Distrikt führt (S. 631—632) über den Höhenstufen von *Pinus ponderosa* und *Murrayana* in der Bergflora *Poa alpina* zwischen endemischen *Carex*, Caryophylleen und *Viola blanda* an, *Phleum alpinum* auf Bergwiesen gegen 3000 m hoch, noch höher auf den San Jacinto Mts. *Oxyria digyna* mit *Draba* und *Pedicularis*, *Antennaria alpina* und eine Form von *Alsine verna* (S. 633). Noch weiter im Süden, auf den Hochwiesen der vereinigten Kordillerenregion scheinen von den arktisch-borealen Charaktergattungen wie *Pedicularis*, *Arabis*, *Ranunculus*, *Draba* nur endemische Montanarten noch vorzukommen, z. B. *Draba tolucensis* und *popocatepetlensis* (S. 652—654), allerdings neben einigen gemeinen borealen Arten von weiter Verbreitung wie *Brunella vulgaris*. — Um das Interesse der ersteren zu erweisen, sei auf die *Potentilla candicans* H. B. Kth. hingewiesen, die einen großen Teil des alpinen Rasens bildet (S. 652) und unter der Sektion »Multijugae« in ihrer dichten silberweißen Seidenbekleidung habituell so einzig dasteht, daß RYDBERG aus ihr eine besondere monotypische Gruppe hat machen wollen (Dr. TH. WOLF: Potentilla, pag. 499); während diese Art in Zentral-Mexiko verbreitet zu sein scheint, ist eine andere, *P. Richardii* Lehm., lange Jahre nur vom Pik von Orizaba in 3700 m Höhe bekannt geworden, bis PURPUS i. J. 1903 auch auf dem Vulkan Ixtaccihuatl eine Zwergform von ihr auffand (Dr. WOLF, l. c. p. 399).

So finden wir mit abnehmenden Breiten eine in den Subtropen zunehmende Fülle jüngerer — oder im älteren Montanelement aus gleicher Wurzel hervorgegangene altangesessene — Arten der zirkumpolar-borealen Stämme. Und zwischen diese mischen sich hier, nahe an den tropischen Grenzen, australe Gattungen wie *Acaena*; am Vulkan Irazu steht neben *Castilleja irasuensis* und *Hieracium irasuense* auch *Pernettya coriacea* (S. 671).

*Waldelemente.* Habe ich so an der Hand des »Survey« auf die Arealstudien im boreal-alpinen Florenelement hinweisen können, zu denen derselbe direkt durch Verbindung der im Abschn. III und IV getrennt behandelten Gesichtspunkte einladet — und es war notwendig für die klare Disposition, dieselben getrennt zu behandeln — so liegt es fast noch näher, die entwicklungsgeschichtlichen Prinzipien an den im Abschn. IV so eingehend behandelten Waldformationen zu verfolgen.

Die Waldespracht von Nordamerika ist oft mit Begeisterung behandelt; sie liegt dem Mitteleuropäer im Bereich großer Gärten durch die vielen Repräsentanten unserer Kultur, welche im Freien aushalten, in schönen Stichproben vor Augen; sie ist zur pflanzengeographischen Gliederung von C. S. SARGENT benutzt worden mit einer Karte, welche die berühmte geographische Anstalt von PERTHES-Gotha veröffentlichte und SCHIMPER noch einmal seiner »Pflanzengeographie auf physiolog. Grundlage« beigab (Karte 4, 1898); seit MICHAUX' Zeiten haben sich viele Reisende, auch Deutsche, mit dem nordamerikanischen Walde beschäftigt, und Prof. MAYR hat ihm in jüngerer Zeit ein sehr beachtens-

wertes Buch gewidmet, welches — nebenbei gesagt — merkwürdigerweise in keiner der großen Philadelphia-Bibliotheken zu finden ist.

Vergleicht man die SARGENT-PERTHESsche Waldkarte mit HARSHBERGERS Figur 4 (S. 206) in den dort dargestellten Ausbreitungs-Richtungen von den durch das Landeis eingeengten Rückzugs- und Umbildungsstätten der pleistozänen Flora, vergleicht man ferner die in Waldkolorit angelegten Vegetationsregionen von HARSHBERGERS Karte, so sieht man sofort den inneren Zusammenhang zwischen geologischer Entwicklung, Ausbreitung des Waldes und Gliederung der nordamerikanischen Vegetationsregionen gemäß dem Dasein oder Fehlen, bzw. der floristischen Zusammensetzung des Waldes.

Über die in Fig. 4 recht klar zutage tretenden Entwicklungszentren der nordamerikanischen Flora hat HARSHBERGER im Januar 1905 in den Proceedings of the Academy of Natural Sciences, Philadelphia, die Grundlinien veröffentlicht, welche der Survey nur weiter ausführt. HARSHBERGER setzt voraus, daß bei der frühzeitig angedeuteten Trennung Nordamerikas in eine östliche und eine westliche Sektion vielleicht schon im Tertiär der Laubwald im Osten, der Nadelwald im Westen prädominierte, und daß dann nach dem Rückzuge des prächtigen Miocänwaldes mit Sequoia, Cinnamomum und Palmen von Grönland bis zum Mississippibecken am Schlusse der Eiszeit aus dessen Resten eine neue, der Vorzeit in den Typen entsprechende Neubesiedelung sowohl vom Osten als vom Westen ausging. Die fünf großen postglacialen Ausbreitungsgebiete *Nordamerikas* umfassen demnach den *Laubwald* des *Ostens*, die *Prärieflora* des *Innern*, den *großen Coniferenwald* des pazifischen Westens, die xerophytische Wüstensteppenflora des mexikanischen Tafellandes, endlich Anteile der südamerikanischen Tropenflora.

Aus diesen fünf Zentren sind im »Survey« insofern sieben geworden, als erstens die arktische Flora auch nach ihrer heutigen Beschränkung als eigenes Element mitzuzählen ist, und zweitens die Tropenflora in zwei Sondergebiete (Festland und Antillen) zerfällt wurde.

Den Charakter solcher Entwicklungszentren findet HARSHBERGER in der Ansiedelung daselbst der allerverschiedenartigsten Formen eines bestimmten Typus, (»location of the greatest differentiation of type«), im größten Reichtum daselbst an herrschenden Individuen dieses Typus, in der Zwischenmischung von besonderen endemischen Arten, und in der Einheitlichkeit und in der Konvergenz der Verbreitungsrichtungen nach diesem Zentrum hin.

Die Zahl der ökologisch gut unterscheidbaren hauptsächlichen Waldformationen ist naturgemäß noch größer, als sie sich aus der eben angegebenen Zahl und Lage der Verbreitungszentren dafür ergeben würde. Denn zunächst zählt die zunächst am Eisrande im Innern des Kontinents um den 40° n. Br. und auf den Bergeshöhen befindlich gewesene boreale Flora, welche dem sich zurückziehenden Eise folgte, unter den Elementen teils selbständig, teils in bedeutsamen Mischungen zwischen den mit reichem Endemismus ausgestatteten südlicheren Entwicklungsgebieten mit, außerdem gliedern sich die letzteren

selbst nach klimatisch-edaphischen Grundsätzen in eine größere Zahl selbständig nebeneinander bestehender Formationen. Darnach scheint mir eine Gliederung der nordamerikanischen Waldformationen, auf welche diese Gesichtspunkte zusammen Einfluß nehmen, in der kürzesten Weise so etwa zusammenzufassen zu sein:

1. Boreale und montane Wälder vom subarktisch-borealen Charakter, in den drei Hauptarealen 1) des Nordens, 2) der östlichen und 3) der westlichen Gebirge.
2. Humose Laub- und »deciduous hardwood« - Wälder im Appalachischen Entwicklungsgebiet.
3. Die südliche Gruppe derselben Laubwälder mit z. T. immergrünen Formelementen. Im appalachischen Gebiet knüpfen sich diese beispielsweise an die Verbreitung der »Live Oak« *Quercus virens* Ait. = *sempervirens* Walt. = *virginiana* Mill. an, deren Areal von Cuba, Costarica und dem nördlichen Mexiko in die Louisiana-Territorien hinein bis zum südlichen Virginien sich erstreckt, in Alabam aselten über den 31° n. Br. hinaus. Im pacifischen Entwicklungsgebiet knüpfen sie sich beispielsweise an *Umbellularia* und *Castanopsis* an, welche letztere ihre Verwandten im tropischen Indien und Himalaya hat, so daß hier Verbindungen zwischen dem arktotertiären Florenelement und der Tropenflora vorliegen.

   Die Sumpfwälder im Küstengebiet mit gleichem Einschlag (S. 213, Fig. 5) bilden in dieser Gruppe eine besondere edaphische Formation.
4. Die xerophytischen »Pine barrens« des östlichen Entwicklungsgebietes um das System der Appalachen.
5. Die xerophytischen Mengwälder im Übergange des mexikanischen Entwicklungsgebietes zu den südlichen Felsengebirgen im Binnenlande.
6. Der Tropenwald und tropische Bergwald mit dem an Südamerika sich anschließenden Hauptcharakter.

Daß beim Zurückweichen des Eises die subarktischen Waldformationen in Canada ihre Elemente aus dem Osten erhielten, erklärt HARSHBERGER daraus, daß die Vergletscherung an der pacifischen Küste viel länger die dortigen Berg- und Hügelketten besetzt hielt (S. 208), und so wird die Ausbreitung vom atlantischen Zentrum näher erörtert (S. 209—11). Die borealen, subarktischen und montanen Waldformationen selbst sind dann in ihren sie zusammensetzenden Gliedern ausführlich im Abschn. IV unter Labradordistrikt (S. 351) und Mackenziedistrikt (S. 356) bis Alaska (S. 358) beschrieben, denen dann die weiteren Formationsschilderungen für die Große Seenregion folgen (S. 360—364), hier schon Nadelwälder mit der Betula—Fagus—Assoziation einschl. Ulme, Linde und Walnuß gemischt (S. 362), wobei auf die schon oben (S. XXV) angeführten Vegetationslinien der Hauptkarte zurückverwiesen werden mag.

Die nordischen Bergwälder finden ihre Charakterisierung in den Schilderungen von Neu-England (S. 370, 374, 377), Adirondacks (S. 403—405), Piedmont (S. 469, 475, 479), und die Schilderung der am weitesten nach

Norden sich erstreckenden »hardwoods« von Eichen mit *Liriodendron* und *Sassafras* findet sich für Massachusetts—Rhode Island auf S. 389, für das Inland ein Gemisch von Eichen mit *P. Strobus* und *resinosa* innerhalb des südlichen Seendistriktes S. 391—393. — Um die Elemente dieser borealen Wälder an der pacifischen Westküste südwärts bis zu ihrem Gemisch mit den arkto-tertiären Reliktelementen zu verfolgen, dienen die Formationsschilderungen in Abschn. IV, Kap. 4, S. 588, 594—599, 601, und verschiedene Stellen der Californischen Region S. 602 ff.

In Alaska treffen im nördlichsten Walde die pacifischen Elemente zusammen mit dem allgemein boreal-subarktischen Walde von Canada; dieses Zusammentreffen schildert HARSHBERGER S. 588 unter Rückverweisung auf S. 208. Der canadische Wald besetzt das Innere von Alaska, die pacifischen Bäume gehen nur im engen Küstenbezirk vom Puget-Sund vor und ähneln in ihrem Gemisch denen des westlichen Britisch-Columbia. Doch ist der Bestand noch recht arm an Arten, so dicht er an Wuchs ist, und besonders die charakteristischste Art selbst, *Pseudotsuga Douglasii*, erreicht Alaska nicht (siehe Karte mit Vegetationslinie), wohl aber *Chamaecyparis nootkatensis*, und überwiegend sind *Picea sitchensis* mit *Tsuga Mertensiana*.

Ein hohes Interesse beanspruchen dann noch die borealen Elemente in der Rocky Mts. Region, in der allerdings nur auf den nördlichen Ausläufern dieselben Arten, wie in Canada und auf den Bergen von Neu-England, wiederkehren, (besonders *Picea alba*, welche die modernisierte Nomenklatur in Amerika jetzt *P. canadensis* nennt). Sonst wachsen hier entweder die Arten der pacifischen Küstenregion wie *Pseudotsuga*, auch noch *Tsuga Mertensiana* stromauf am Fraser R. in den Selkirk Mts., oder aber eigene, auf weite Areale ausgedehnte Arten vom gleichen Gattungsstamme der Lärchen, Tannen und Kiefern, unter ihnen hervorragend *Larix occidentalis* und *Lyallii* im nördlichen Distrikt der Rocky Mts. (S. 548), *Abies subalpina* und *Pinus ponderosa* bis 51½° n. Br. Auch die subalpinen Waldformationen zeigen darin kein anderes Bild, sondern erhalten durch *Pinus albicaulis*, *Picea Engelmannii* und *Pinus Murrayana* noch besondere Charakterzüge (S. 549), so daß erst eine Stufe höher, in den alpinen Fels- und Mattenformationen, die arktisch-borealen Arten selbst in großer Anzahl wiederkehren (siehe pag. L). —

Die Entwicklungsgeschichte des Rocky Mts.-Systems ist besonders S. 241—243 behandelt von der Zeit an, wo die riesigen (an 3000 m Tiefe haltenden) Kreidesedimente sich hoben, ebenso den Felsengebirgen parallel die Küstenkette, zwischen ihnen das hohe Tafelland und mächtige Seen, welche auf ein viel feuchteres Klima hindeuten als gegenwärtig hier herrscht, und die demnach eine reiche pliocäne Waldflora mit Vorwiegen der (ursprünglich getrennt für sich entwickelten) westlichen Elemente zur Ausbreitung gelangen ließen. Ein solcher See dehnte sich in Utah aus, ein anderer vom nordwestlichen Nevada bis Californien. Damals lebten noch Arten von *Sequoia*, *Glyptostrobus*, *Ficus*, *Caesalpinia* u. a. jetzt verschwundenen Gattungen hier. Später griff das trockne Klima um sich und ließ die Scheidung zwischen

Steppenformationen und den mit resistenten Baumarten besetzten höheren, feuchtkühlen Waldformationen der Gegenwart sich vollziehen: siehe S. 243 mit den Elementen der drei aufeinander folgenden Höhenstufen, die dritte S. 253.

Die oben genannten Nadelhölzer herrschen, mit Beschränkung der *Larix Lyallii* auf die Bitterroot Range, auch in den südlichen Rocky Mts. mit neu hinzukommenden Arten derselben Gattungen, unter denen besonders die Kiefern an Zahl und Bedeutung zunehmen (*Pinus aristata, edulis, flexilis, monticola* neben den früheren), und zu denen die Gebirgs-Tsuga, *T. Pattoniana*, mit breitem Areal an Stelle der *Tsuga Mertensiana* sich gesellt (S. 551—556). Die z. T. aus gleichen Arten bestehenden Formationen der Cascaden-Berge, Vancouver-Insel und anderer westlicher Küstenbezirke siehe S. 594—596, deren Studium immer von neuem die mächtige Präponderanz der Coniferen in diesem feuchtkühlen Seeklima beweist, da die wenigen Laubhölzer auf eng umgrenzte Standorte in den Talsohlen beschränkt sind.

Eine vortreffliche Übersicht dieser westlichen Waldelemente liefert der Abschn. III, S. 263—272, wo Areal- und Höhentabellen besonders für die Sierra Nevada (S. 267) ihren Platz gefunden haben.

Es erschien nützlich, die auf ein großes Areal durch viele verschiedene Vegetationsregionen ausgedehnten borealen Waldelemente in ihren z. T. prächtig lokalisierten vikariierenden Arten zu verfolgen; die übrigen oben (S. LIII) unterschiedenen Waldformationen halten sich naturgemäß viel enger an eins der Haupt-Entwicklungszentren.

Aber in demselben gibt es dann die inneren Formationsgrenzen, welche gleichzeitig, durch Gebirgsbau und Boden veranlaßt, engere entwicklungsgeschichtliche Grenzen darstellen. Eine solche behandelt z. B. HARSHBERGER bei der Charakterisierung der Waldflora des Piedmontdistrikts gegenüber den Pine barrens der Küstenniederung (S. 461). Die erstere setzt sich aus breitlaubigen Gehölzen mit entsprechendem Unterwuchs von Strauch und Kraut zusammen (Liste für New Jersey S. 461 Abs. 4). Zuweilen bilden sich Mischgebiete heraus, in denen man den Kampf der Laub- und Nadelwaldflora verfolgen kann, wie gerade an den nördlichen Ausläufern des Piedmont-Plateaus, wo es bei Trenton den Delaware R. überquert. Die Schilderung der zugehörigen Waldformation, wie sie in unmittelbarer Nähe von Philadelphia noch fast ganz urwüchsig zu finden ist, erläutert das entwicklungsgeschichtliche Bild (S. 465—6). Alles Kulturland ist hier aus dem Walde entstanden, der ursprünglich fast die ganze Oberfläche des südöstlichen Pennsylvaniens bedeckte und dessen Tendenz nach der Vorherrschaft der sog. »mesophytischen« Vegetationsformen ging. Hier konnten sich wegen der starken Winterfröste in diesen Territorien nur die wirklich harten Gehölze des ursprünglich reichhaltiger zusammengesetzten miocänen Waldes halten, deren Liste ausführlicher angegeben wird.

Südlich von diesem Walde begegnen wir dann in dem Appalachendistrikt einer zunehmenden Fülle von frostempfindlichen Arten, aber deren Hauptmasse ist erst in der die Appalachen umrandenden Golfküstenregion zu suchen,

in den Dünenwäldern von Carolina und südwärts, wo bis zur Breite von Virginien herauf die immergrüne *Quercus virginiana* (*virens*) als Zwergbaum sich einmischt (S. 431), *Sabal Adansonii* die Zwergpalmen starkwüchsig vertritt (S. 432), und endlich *Sabal Palmetto* seine Nordgrenze erreicht (S. 433).

Von besonderem Interesse sind dann wiederum die »Pine barren« Formationen, deren Eigentümlichkeiten S. 220—222, dann hinsichtlich ihrer subtropischen Glieder S. 231 ausführlich behandelt sind. Auch nach der Richtung hin, daß merkwürdigerweise in einer doppelten Anpassung mancher Arten spezifische Merkmale der Montanflora sich in der Küstenniederung wiederholen (S. 220—1); die auffälligen Standorte betreffen Glazialpflanzen wie Ericaceen und *Scheuchzeria*, diese naturgemäß nur im nördlichen Küstendistrikt dieser Formation. Dieselbe behält am zweckmäßigsten ihren englischen Namen, um nicht ohne weiteres mit den mitteleuropäischen Heidewäldern von *Pinus silvestris* verwechselt zu werden. Die Pine barrens und die ihnen angeschlossenen Strandformationen von Long Island bis Florida decken einen verhältnismäßig jung-geologischen Kreide- oder Tertiärboden (S. 408), auf denen wandernde Sanddünen mit dem Walde kämpfen (S. 413, Fig. 23 S. 414), und Dickichte, undurchdringlich von *Smilax* und *Ampelopsis*, mit Beständen von *Juniperus virginiana* und reicheren, dem »Wildwood« Bestande (S. 417), abwechseln. Hier herrscht an den Nordgrenzen der Formation zunächst *Pinus rigida* mit 5 Eichen (S. 421), unter ihnen auch *Qu. ilicifolia* als gebüschbildendes Niederholz, wie sie sich noch weit den Hudson R. hinauf findet; an anderen Stellen teilt sich das Gelände in Kiefernbestände und in solche, in denen Laub- und Nadelhölzer zusammen vorkommen, was oft von der Art des Untergrundes abhängig ist (S. 423—424). Auch Oak-Barrens kommen für sich allein vor (S. 425). Südwärts folgt dann auf den Dünen schon *Pinus Taeda* im Carolina-Stranddistrikt (S. 431, 433) mit der schon mehrfach erwähnten immergrünen Eiche, während landeinwärts Bestände von *Pinus palustris*, *Taeda*, *serotina* und *mitis* rein oder gemischt herrschen und Laubwaldungen anders als in Einmischung untergeordneter Art nicht aufkommen lassen (S. 434). Bis zu 200 m Höhe können sich kiefernbedeckte Hügel erheben über niedrigere Ebenen, welche alle auf Hunderte von Quadratmeilen ohne Unterbrechung von *Pinus palustris* eingenommen sind (S. 435). In Südcarolina unterscheidet man zwischen »Loblolly-Pine barrens« von *P. Taeda* und den »Longleaf-Pine barrens« von *P. palustris* (S. 436—437); in den Depressionen aber gedeihen Sumpfwälder von *Nyssa* und *Taxodium* (Taf. X, S. 439). Die subtropische Golfküste bis zur Distriktsgrenze in Texas hat manche neue Arten aufzuweisen, darunter auch in den Pine Barrens die *Pinus caribaea*, welche sich mit den beiden vorigen mischt (S. 446); aber auf dem welligen Inlande bis zu Höhen von 300 m sind dann wiederum ausgedehnte Longleaf-Pine barrens in fast ungebrochen reinen Beständen zu finden (S. 449). Eichen mit *Chamaecyparis thyoides* wachsen in den Depressionen und auf den Sandbänken der Flüsse (S. 450); aber auch auf den 300 m übersteigenden Erhebungen lösen Hartholzwälder die Pine Barrens ab, bedecken in Texas weithin zusammenhängende Streifen Landes mit einer

Menge von Eichen, Carya, Nyssa u. a. A. (S. 451). Indem nun in dem Arkansas-Louisiana-Distrikt der nach den Pine Barrens benannten Region die Longleaf Pine (*P. palustris*) fehlt und wieder durch *P. mitis* ersetzt wird (S. 454), zugleich auch die Arten der Laubgehölze im unteren Alluvial-Lande besonders reich sind (S. 456—457) und dort die Pineten völlig ersetzen (S. 458), kommt ein Anschluß an die inneren Territorialformationen heraus. Vielleicht ist diese Pine Barrens-Region die einzige in der Welt, in der von einigen wenigen sich ablösenden Arten der Gattung *Pinus* in regelmäßiger Aufeinanderfolge und Zwischenmischung so viel zusammenhängender Wald gebildet wird.

Sowohl entwicklungsgeschichtlich interessant in Hinsicht auf die sich zusammenfindenden Arten, als auch ökologisch durch die Blattorganisation, sind die kleinen Waldungen, die sich in der Umrandung der Bergwaldungen in den südlichen Rocky Mts., auf dem Coloradoplateau und an den Flanken der Wahsatch Range finden und die die Karte von SARGENT (SCHIMPERS Pflanzengeographie) als »Wälder des Binnenlandes« bezeichnet. Über den Buschdickichten von *Fouquiera* und *Larrea* mit Mesquite-Bäumen (*Prosopis juliflora*, S. 574—576) kommen in den höheren Lagen harte Kiefern (*Pinus edulis*) in Gesellschaft von Wacholderarten, Eichen und *Rhus aromatica* mit *Yucca* und *Opuntia* vor; in den Bachtälern wachsen Pappeln und Platanen als hygrophile Elemente (S. 579—581). *Robinia neomexicana* spielt eine große Rolle. Zwischen der Sierra Nevada und dem Colorado findet sich ein 600 m breiter Gürtel von *Pinus monophylla* mit *Juniperus utahensis*, höher hinauf *P. flexilis* und *P. aristata* (S. 586—587). Eine Liste derjenigen Bäume, welche nördlich von der mexikanischen Grenze die Territorien zwischen dem Ostfuße der Rocky Mts. und dem Ostfuße der Sierra Nevada nebst Cascadengebirge besiedelt haben, in welcher sich also Pinus und Larix mit Quercus, Prosopis, Yucca und Cereus mischen, findet sich S. 244—245, und die folgenden Seiten enthalten höchst wichtige Zusammenstellungen der Arealverbreitung von Gehölzen in den nördlichen Felsengebirgen, im Great Basin (S. 250) und in der dürren Region von Neu-Mexiko und Südcalifornien (S. 251—253).

Die Elemente der tropischen Waldflora haben ja im allgemeinen in Nordamerika gut abgeschlossene Ausbreitungsareale angenommen, weil der im Bereich des nördlichen Wendekreises vorgelagerte Gürtel weitgedehnter xerophytischer Formationen nur eine kleine Ausdehnung der Mischungsgebiete zuläßt. Am bekanntesten ist Florida in seiner von Süden her erfolgten Invasion tropischer Elemente; den Bäumen schließen sich aber auch mancherlei Gräser, Cyperaceen und dikotyledone Stauden an, für welche S. 226—227 Beispiele liefert. Der Vergleich von Florida mit den Bahamas führt zu einer hübschen Tabelle, in welcher auch die Arealausdehnung auf die Antillen durch Signaturen erläutert ist (S. 229), und die sich anschließenden Auseinandersetzungen sind der besonderen Stellung von Florida gewidmet. Die Beschreibung der Formationen trennt naturgemäß die nördliche Halbinsel als zum Pine Barren-Stranddistrikt gehörig (S. 438, 441) von der tropischen Südspitze, welche an die Bahamaregion angeschlossen erst im letzten Kapitel des Buches folgt

(S. 695—700). Die übrigen tropischen Elemente, soweit sie nicht zu der xerophytischen Wüstensteppenflora gehören, sind im Abschnitt III Kap. 3 § 7 (S. 300—311) im Zusammenhang von Zentralamerika mit den Antillen behandelt.

*Grasland und Xerophyten.* Von den sieben großen Bereichen mit eigenen Entwicklungsformen, welche von HARSHBERGER als vor der Glazialperiode bereits *in situ* angenommen werden (S. 310—311), bleiben nunmehr noch die Entwicklungsverhältnisse der Grasland-Flora und der Mexikanischen Hochland-Flora zu betrachten übrig, dieser so hoch interessanten Floren, welche in einer durch den Kontinent auf etwa 40 Breitengrade durchgehenden Sperre (20° N. bis 60° N.) die Gebirgs- und Niederungsfloren der östlichen und westlichen Gebiete geschieden gehalten haben. Es ist wichtig, sich daran zu erinnern, daß in frühen Zeiten geologischer Entwicklung gerade an den Stellen, wo jetzt ein Hauptteil dieser xerophytischen Floren sich ausbreitet, das Meer durchging (Fig. 2, S. 172), daß noch zur Tertiärperiode große Binnenseen hier übrig geblieben waren (Fig. 3, S. 179), und daß dann zur Glazialperiode nach Fig. 4 (S. 206) die Wüstensteppenflora und die Graslandflora in ganz dicht aneinander schließenden Territorien ihre besondere Ausbildung und den interessanten Reichtum an Arten entfalteten.

Hier knüpft zunächst die entwicklungsgeschichtliche Betrachtung der Flora des Mississippi-Tales an (S. 232), dessen Besiedelung sich aus dem südwestlichen Steppenelement, aus den unmittelbar im Osten angrenzenden Prärien, aus den von Westen von den Rocky Mts. herkommenden Arten und aus einer Reliktflora zusammensetzte, welche letztere auch in den Zeiten einer zunehmenden Dürre dort verblieb und die westliche Waldflora zurückhielt. Jedenfalls gab es nach des Verf. Meinung ein Gras bedecktes Prärieland auf beiden Seiten des Mississippi, in welche dann erst später die Elemente der sog. Sonora-Flora (s. oben S. XXX) sich eingemischt hätten. Dabei kommt die Frage der Waldlosigkeit, westwärts vom Mississippi auch die der Baumlosigkeit zur Diskussion (S. 233), wobei ein Zusammenfallen mit den Kurven der Regenhöhe in Abrede gestellt wird, ebenso wie die äerische Bildung großer Flächen heutigen Prärielandes neben der limnischen in älteren Perioden festgestellt wird (Löß, S. 233—235). In den vorhergegangenen physiographischen Bedingungen dieser Region zusammen mit der Lößbildung und den sich steigernd trocknen Sommern findet HARSHBERGER sehr richtig die Ursache zur Entstehung der großen baumlosen Ebenen (S. 235). Nur wenn die Waldkette des Ostens »in solider Phalanx« fortschreitet, kann sie über das Grasland die Oberhand gewinnen. Die Grasformationen sind endemisch; die Besiedelung mit Bäumen, welche fast gänzlich aus dem Südosten entsprang (S. 237), ist solche sekundärer Natur (S. 236).

Das Entwicklungszentrum der Prärien liegt in Nebraska, Jowa, Kansas und den beiden Dakotas, also in dem um das Ozarkplateau herum sich ausdehnenden mittleren Präriengebiet (S. 237 und 519). Merkwürdig wenig Bäume sind in dies Gebiet von Westen her eingedrungen; die Liste S. 237 deutet 10 Arten an; zuweilen treffen östliche und westliche Besiedelungselemente

miteinander zusammen. — Nunmehr werden die einzelnen Teile der höher aufwärts liegenden Wüstensteppen durchgesprochen, die Sandhill-Region (S. 238), die Foothill-Elemente im Great Basin (S. 239), und es wird ihre Vermischung in die Bergfloren der Rocky Mts. nach floristischen Arealen, besonders denen der untersten trocknen und baumlosen Distrikte in diesem riesigen Berglande auseinandergesetzt (S. 243), dessen obere Regionen schon unter Wald- und Hochgebirgsflora mit alpinen Formationen ausgeführt sind.

Im Verfolg aller dieser leitenden Grundsätze sind dann im vierten Hauptabschnitt die Formationen der Prärieregion breiter dargestellt unter Ergänzung dessen, was in Abschn. III über die geologische Entwicklung gesagt war, durch floristische Untersuchungen der Gegenwart (S. 516—519) mit Anführung der endemischen Arten; sie gehören zu Gattungen, die meistens auch im Appalachengebiet vorkommen. Die Formationen gliedern sich bekanntlich so, daß auf ein Übergangsgebiet mit Laubbäumen (Eichen! Hickory und Ahorn, Gleditschia usw., S. 519—522) und mit Präriefluren auf feuchtem und trocknem Grunde (S. 522—525), die eigentlichen echten Prärien auf Lehmboden und auf Tonboden westwärts folgen (S. 526—531) mit den geselligen Hauptarten je eines *Sporobolus*, *Koeleria*, *Eatonia*, *Panicum*, ferner *Bouteloua* und *Andropogon* als sekundär wichtiger Gattungen. Auf sie folgen die Sand Hills mit den Bunchgras-, Blowout- und Sanddraw-Formationen (S. 532) bis zum Foothill-Distrikt, in welchem die Stipaformation und die Grama-Grasformation von Bouteloua überwiegen (S. 536—538).

Eine Sonderstellung hat das Great Basin, welches seine geographische Breite mit dem Zentrum der Prärien von Kansas bis Norddakota teilt, von diesem aber durch den Gebirgswall der Rocky Mts. getrennt ist und dafür im Lauf des Colorado mit dem eigentlichen Sonora-Entwicklungsgebiet zusammenhängt. Hier strahlen daher die Areale mancher Arten des mexikanischen Plateauelements aus, wofür eine kleine Tabelle S. 250—251 deutliche Beispiele bringt.

Die theoretische Vegetationskarte der Eiszeit (S. 206) setzt die Nordgrenze der damaligen Entwicklung dieser Wüstensteppenformation etwa zwischen 30°—35° n. Br. fest, während jetzt die Ausdehnung der Great Basin-Vegetationsregion um mehr als 10 Breitengrade höher nach Norden geht. Die Flora der südlich vom Canyon des Colorado liegenden Wüstensteppen ist daher als die älteste und ursprünglichste anzusehen, ihrer floristisch-entwicklungsgeschichtlichen Betrachtung widmet HARSHBERGER den § 6 in dritten Kapitel seines Abschnitts III (S. 282—300). Es ist bekannt, daß die fossilen Pflanzenreste sich längst nicht auf alle früher herrschend gewesenen Formationen beziehen, daß beispielsweise aus Skandinaviens Diluvialflora die Wald- und Torfmoorelemente in großer Vollständigkeit bekannt geworden sind, während alle Xerophyten fehlen; man darf annehmen, daß die Bedingungen der Fossilisierung der letzteren überall sehr ungünstig gewesen sind und daß man daher mit paläontologischen Funden hier nicht so rechnen darf wie etwa bei der Waldflora. Die Entwicklungsgeschichte kann daher hier in der Hauptsache nur die frühere Landgestaltung und Physiographie nebst den Arealen der jetzt

herrschenden *Formationsglieder und deren systematischer Stellung zum Untergrund* der Betrachtung nehmen.

So bespricht der Verf. hier die Areale des Kreosotstrauchs, *Larrea mexicana*, verschiedener Cactaceen (S. 296), der *Yucca*, der Charakterarten von Artemisia (*A. spinescens*, *tridentata*), der Salzpflanzen *Sarcobatus*, *Halostachys*, *Atriplex*, *Salicornia* und *Suaeda*, dazu die artenreichen endemischen *Eriogonum*, *Astragalus*, *Gilia*, welche zur Gliederung dieser Wüstensteppen in die drei Regionen (Great Basin, Sonora, Chihuahua: siehe oben S. XXXVI, XLII) geführt haben, und bespricht eingehender einzelne der durch Endemismen ausgezeichneten Wüsten, Colorado- und Mohave Desert (S. 289). Von Florenelementen lassen sich allerdings nur zwei unterscheiden, das Great Basin-Element und das von Nordmexiko; *das erstere hat sich voraussichtlich gleichfalls schon vor der Haupteiszeit* ausgebildet und nach derselben seine starke, durch das trockne Klima bedingte Ausbreitung erlangt (S. 294); von dem Ringen der verschiedenen Florenelemente gegeneinander gibt der in jüngster Zeit erfolgte Ausbruch des Colorado in der nach ihm benannten Wüstensteppe (Anm. 3 auf S. 293) ein hübsches Beispiel. — Die Flora von Nordmexiko ist charakterisiert durch das Fehlen von 39 Pflanzenfamilien von tropischem oder hygrophilem Charakter (S. 295); sie entspricht darin also durchaus den Merkmalen subtropischer Wüstensteppen. Auch hier gehören die interessanten Einzelheiten des IV. Abschnittes zur Ausfüllung des groß gespannten Rahmens (IV. Kap. 5, S. 633, 643 und ff.). Die Assoziation von *Larrea* beherrscht am Unterlauf des Rio Grande und Gila-Flußes das Feld; die Palmengattung *Washingtonia* (S. 636) würde ein Endemismus des alt-tertiären Typus sein. Wiederum von bemerkenswert eigenartigem Charakter sind die Inseln an der Küste von Niedercalifornien (S. 639), unter deren 135 Arten sich eine Reihe von Endemismen befindet. — Die Steppen von Chihuahua beherrscht der Kaktus-, Yucca- und Agave-Typus (S. 643), dazu Larrea oft als einzige Art wie in einer Pflanzung. Andere große Familien sind durch Reichtum an endemischen Arten ausgezeichnet, besonders die Compositen (S. 647: Tabelle von 70 Arten).

*Es ist noch ein interessantes Gebiet in der floristischen Entwicklungsgeschichte* der Union übrig geblieben, nämlich das des pazifischen Küstenstriches südlich von der allgemeinen Ausbreitung der borealen Elemente (Anschluß an Seite LIV—LV). Mit Vorrücken in die subtropischen Breiten südlich vom 40° n. Br. nimmt zunächst der Endemismus in den borealen Gattungen stark zu, wofür der Vergleich von *Ribes*-Arten in der Küstenregion und der Sierra Nevada (S. 273) *ein vortreffliches Beispiel gibt, wenn auch der Wert* der Menge neu unterschiedener Arten immerhin noch etwas problematisch bleibt. Indes ist doch wohl die Meinung richtig, daß die Flora dieser südlichen Küstenkette entschieden endemisch und die bei weitem älteste und einheitliche in diesen Territorien ist (Liste S. 274), die dann also nach meiner Meinung als ein besonderes Glied der arktotertiären Flora zu gelten hätte; in ihr sind aber viele Gattungen enthalten, welche aus der europäischen Arktotertiärflora nicht bekannt geworden sind, wie überhaupt alle boreal-alpinen Gattungen der

Gegenwart dort fehlen. Um so interessanter ist es, daß diese Artgenossenschaften (HARSHBERGER führt dafür als englischen Terminus die Bezeichnung »*Species guild*« ein) von Oregon und Washington her der Redwood-Formation (siehe S. 605) folgen! Ihm begegnet naturgemäß das sonorische Florenelement von Süden her in andern Formationen, so daß, im Zusammenhange mit dem stark endemischen Charakter der Flora, sich hier im Cismontanen-Distrikt (S. 274) eine vielseitige Flora zusammendrängt. Sie hat ein besonderes Prüfungsmittel noch in den Inseln an der Küste von Californien (S. 275), die nicht nur endemische Arten, sondern sogar Gattungen in Abweichung von der Festlandsflora aufzuweisen hat. Indem sich nun im californischen Festlande ein eigenes dürres Gebiet ausbildete zwischen den Schneebergen im Osten und der Küste, indem den vielseitigsten Wanderungen hier die Wege geöffnet waren, kommt HARSHBERGER zu einer Zusammensetzung der Flora vom südlichen Californien aus fünf Elementen (S. 279).

Die Einzelheiten, unter erneutem Hinweis auf den endemischen Charakter der Flora der eigentümlichen Küstenkette (S. 603), sind dann in Abschn. IV unter Californischer Region abgehandelt (S. 602—633), in welcher auch die Flora der interessanten Inseln S. 621—623 eine Besprechung nach den einzelnen Inseln gefunden hat, nach ihr die gegenüberliegende Küste mit endemischen Arten in den Strandformationen (S. 624) und den Chaparrals; durch den Reichtum an Arten unterscheidet sich diese Landschaft von der im Innern gelegenen San Jacinto: 100 Arten erstrecken sich nicht in das Innere hinein (S. 627).

*Tropenflora.* Der Schluß des entwicklungsgeschichtlichen Kapitels ist der Ausbreitung der Nicht-Steppen-Florenelemente im tropischen Anteil von Nordamerika gewidmet (Abschn. III, 3, S. 300—311). Davon sind die interessantesten Gesichtspunkte naturgemäß die, welche sich aus dem Verfolg der Areale subtropischer Florenelemente aus Territorien wie Texas, Sonora und Californien südostwärts nach Zentralamerika hinein ergeben, sowie die Beziehungen der Antillen sowohl zum westwärts als zum nordwärts von ihnen gelegenen Festlande.

In ersterer Beziehung ist die Chaparral-Vegetation von Bedeutung, welche Texas mit dem nördlichen Yucatan verbindet (siehe Karte: *Golfregion der mexikanischen Florenprovinz*); die Mimoseen und Caesalpinieen bilden 30 % von dieser Formation im Chaparral vom Rio Grande del Norte, einen noch viel größeren Bruchteil des Bestandes, wenn die Geselligkeit in Anschlag gebracht wird, und dieser Charakter geht am Golf in niedere Breiten über, während andererseits der mexikanische Mesquitebaum, *Prosopis juliflora*, sich mehr und mehr über Texas ausbreitet (S. 301, vergl. auch im Abschn. IV, Kap. 6, S. 659—660, 666). — Außerdem ist von großer Bedeutung das Studium der Hochgebirgsfloren in Mexiko (vergl. oben, S. LI). Hier treten in den obersten Stufen boreal-zirkumpolare Gattungen auf wie *Draba*, *Potentilla*, *Carex*, die über den Äquator jenseits hinausgehend ihre Areale bis Chile und zum Feuerlande (S. 304) erstrecken, während sehr wenige der eigentlich amerikanischen, oder mexikanischen, Gattungen die Höhengrenze der Vegetation erreichen (S. 302). Es ergibt sich dies dem Leser leicht beim Durchmustern der

alpinen Formationen am Orizaba (S. 653) und den anderen Vulkankegeln (S. 654—656).

Die südliche Sektion des tropischen Anteils von Nordamerika, nämlich Nicaragua, Costa Rica und Panama, bietet die eigentliche nahe Verwandtschaft mit Südamerika und echte tropische Besiedelung. Aber die große Zahl südamerikanischer Elemente, welche zwar Guatemala und Mexiko, nicht aber die Antillen und Bahamas erreichen, weisen auf eine mehr zurückliegende Verbindung hin (S. 303—4), gerade wie auch Eichen, *Arbutus* und *Chamaedorea* den umgekehrten Verbindungsweg eingeschlagen haben und zeigen, daß in Zentralamerika ein tropisches, ein andines und ein endemisch-mexikanisches Florenelement gemischt die Flora bildet (S. 305).

Der eigenartige Charakter der westindischen Flora dagegen erklärt sich, bei allen Gemeinsamkeiten im tropisch-amerikanischen Typus, aus der altgeologischen Entwicklung, wo die Antillen in wechselnder Landverbindung einen eigenen Kontinent bildeten, der auch mit Florida in Verbindung trat, und von dessen reicher Tropenflora wir jetzt gewissermaßen die fortentwickelten Überbleibsel sehen (S. 306, 309). —

*Die Karte* mit den pflanzengeographischen Arealen, Distrikten und Vegetationsregionen von Nordamerika. — Auf S. 344—345 wird die Entstehung der Karte erklärt, auf welche — als auf eine wesentliche und wichtige Leistung in dem General Survey — im vorhergehenden immer schon Bezug genommen wurde. Man darf annehmen, daß die Einteilung in einzelne Regionen und deren Grenzführung mit so viel floristischer Sachkenntnis und Landeskenntnis vor sich gegangen ist, wie sie nur im Lande selbst in jahrelanger Arbeit hat gewonnen werden können.

Ferner ist durch geschickte Farbenwahl, (welche sich übrigens an die im BERGHAUSschen physikalischen Atlas 1887 angewendete Farbenskala für die Vegetationszonen und -Regionen sehr glücklich anschließt und in der Vertauschung von Blau gegen Rot-Violett für die Tropen eine günstigere Wirkung erzielt), bewirkt, daß diese eine Karte zugleich die Vegetationszonen für Nordamerika (vergl. BERGHAUS Phys. Atlas Nr. 46, Pflanzenverbreitung Nr. III) sehr deutlich zum Ausdruck bringt, während man allerdings ein spezielles Eingehen auf den Florenreichscharakter mit Hervorhebung der hauptsächlichen Entwicklungsgebiete vermißt, bzw. dieselben aus dem Texte in Abschn. III ergänzen muß. Es darf übrigens hier noch einmal darauf hingewiesen werden, daß sowohl der floristisch-entwicklungsgeschichtliche als auch der auf die Vegetationsformationen sich stützende zonal-ökologische Gesichtspunkt, beide zusammen oder jeder für sich, die pflanzengeographische Kartierung beherrschen müssen. Es ist eine Verkennung dieses Prinzips, wenn im Text S. 39—40 unter den früheren pflanzengeographischen Karten von Nordamerika nur die Florenkarte von Amerika in BERGHAUS Atlas Nr. 50 angeführt wird; denn sie stützt sich gleichfalls auf die Einteilung der Erde in Florenreiche und Gebiete, wie sie bereits vor der Ausgabe des BERGHAUSschen Atlas in PETERMANNS Geograph. Mitteilungen 1884, Ergänzungsheft 74 auf den drei Tafeln I, II und III

(boreal, temperiert-subtropisch, tropisch) zur Darstellung gelangte. Auch MERRIAM hat i. J. 1893 eine ähnliche zonale Generalkarte für Nordamerika in nur 6 Abstufungen von Hauptfarben herausgegeben, während die von ENGLER 1902 herausgegebene kleine Karte in Schwarzdruck unter Verwendung von 11 verschiedenen Schraffiersignaturen mehr die Ausbreitung entsprechender Formationsgruppen zum Ziel nimmt.

Es ist nun erfreulich, daß diese älteren Karten im großen ganzen dasselbe Vegetationsbild von Nordamerika gezeichnet haben, was besonders dem frühen Bekanntwerden der Grenzen bestimmter Waldformationen zu verdanken ist; die Veränderungen im »Survey« betreffen hauptsächlich die Zahl der unterschiedenen Regionen sowie deren sorgfältige Grenzführung. An einer Stelle allerdings treten sie prinzipiell umändernd und gewissermaßen reformatorisch auf, indem sie eine neue bildliche Darstellung der Arealumgrenzungen und Formationsmerkmale geben: das ist mitten um den Mississippi und Missouri herum, wodurch mancherlei Veränderungen in dem Gebiet südlich von den großen Seen herab bis zum Golf von Mexiko geschaffen werden. Umgrenzung des Alleghany-Ozarkdistrikts, welcher durch die tiefe Einbuchtung der Atlantischen-Golfküstenregion im Tale des Mississippi einen westlichsten, von den Prärien umringten Abschnitt frei läßt, und die Zusammenfassung der sich kreuzenden Areale in Übergangslandschaften scheint eine glückliche Lösung hier zu bieten. Und das Rückgrat dieser ganzen Regionsgruppe bildet dann die Region des Appalachensystems. — Andere Regionen, beispielsweise die der Rocky Mts., erscheinen der natürlichen Grundlage nach notwendigerweise mit künstlich abgeschnittenen Grenzen, bei einigen anderen kann man zweifelhaft sein, ob sie ganz das Zweckmäßige treffen. So versucht z. B. die erwähnte BERGHAUSsche Atlaskarte Nr. 50 die Grenze der jetzigen Sonoraregion gegen die nördlich angrenzende des Großen Bassin nach den Arealen von Yucca, Larrea, Cereus giganteus u. a. praktisch zu wählen, während HARSHBERGER an dieser Stelle keine besondere Rücksicht darauf nimmt. Da er im übrigen nicht in Einzelheiten seiner Grenzbildung eingeht und die Gründe seiner Veränderungen nicht nennt, auch die Verschiedenheiten, welche die früheren generellen Kartenbilder von Nordamerika aufweisen, nicht kritisch beleuchtet, im übrigen aber bei der Wahl der Regions- oder Distriktsnamen nach dem historisch ältesten sucht, so bleibt hier für weitere Veröffentlichungen das Feld geöffnet. Aber das ist klar, daß jede folgende pflanzengeographische Arbeit über Nordamerikas Gliederung durchaus mit HARSHBERGER's Survey zu rechnen und auf ihm als genau durchdachter Grundlage fußend etwaige Neuerungen zur Diskussion zu bringen haben wird. — Bei einem größeren Maßstabe der Karte würde es dann nahe liegen, die Ausstrahlung der verschiedenen Elemente, der borealen auf den Bergketten nach Süden, der tropischen und subtropischen nordwärts in die borealen Waldgebiete oder in die Prärien hinein, durch farbige Signaturen auch kartographisch zum Ausdruck zu bringen, wie das hinsichtlich des borealalpinen Florenelements gleichfalls schon die Florenkarte von Nordamerika in BERGHAUS' Atlas auszuführen versuchte.

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# Part I.

# History and Literature of the Botanic Works and Explorations of the North American Continent.

## Chapter I. History.

### § 1. Floristic Work.

The botanic history of North America has never been written. The information, therefore, is fragmentary and often published in an inaccessible form. This chapter will be devoted, therefore, to a brief, but comprehensive, account of the most important explorations that have made botanic collection and study a special feature, and to a mention of the principal monographs, manuals, papers and pamphlets which have appeared on the North American flora in general and North American phytogeography in particular. For facility in treatment and also for the purpose of classification the following broad arrangement will be followed in presenting the historic facts which concern this chapter with the following broad classification of material according to geography: I. Canada, II. New England, III. Middle Atlantic States, IV. Southeastern States, V. Prairies, Arid Plains and Rocky Mountains including Great Basin, VI. Pacific Coast, VII. Great Southwest, VIII. Mexico, IX. Central America, X. West Indies.

Because several of the large scientific expeditions were transcontinental, it is impossible therefore, to make a strict geographic classification of the historic material. In the following account, therefore, such expeditions are mentioned in connection with the region with which they were most prominently identified.

### I. Canada.

Passing over the explorations and an account of the voyages of JACQUES CARTIER 1534, CHAMPLAIN 1608, LA SALLE 1679—82, LA HONTAN 1703, we come to DIERVILLE, who visited the coast of America in 1706 and carried back to France a number of plants which were submitted to TOURNEFORT, who dedicated one plant to its discoverer DIERVILLE. MACKENZIE in 1789 penetrated the heart of British North America, but he contributed nothing to enrich

botanic science, nor do HENNEPIN 1679, CHARLEVOIX, LAFITAN add much, although, they describe the common plants. In 1635, however, JACQUES PHILLIPPE CORNUT of Paris published a list of Canadian plants under the title of "Canadensium plantarum alierumque nondum editarum historia". It contains descriptions of a very considerable number of common plants which are figured in admirably executed plates. Dr. SARRASIN of Quebec who sent a number of plants to Europe discovered the pitcher-plant in whose honor it was named *Sarracenia* by TOURNEFORT. In 1749, PETER KALM proceeded by way of Albany and Lake Champlain to Canada making a somewhat prolonged stay at Quebec, where he met Dr. GAULTHIER and discovered the plant dedicated to his friend, *Gaultheria*. The labors of Kalm gave a decided impulse to Canadian botany, as his collections formed so conspicuous a part of the material on which Linnaeus based his descriptions of American plants. Kalm was the first botanist in the field and may justly be regarded as the father of Canadian botany. Following KALM in 1785—86, ANDRÉ MICHAUX, a disciple of BERNARD DE JUSSIEU visited America on a similar mission and in 1792 he reached Montreal and Quebec and proceeded to the lower St. Lawrence, Lake St. John and Mistassini, and thence towards Hudson Bay. On this trip, he determined the northern limit of a number of North American forest trees. His notes and collections served as the basis of his Flora Boreali-Americana which was published by the eminent botanist CLAUDE LOUIS RICHARD in 1803 with descriptions of 1700 plants with illustrations. ARCHIBALD MENZIES was the first English naturalist to enter the field of botanic collections in Canada and although he published nothing of importance yet his collections were important to the science. FREDERICK PURSH made extensive collections in Canada, chiefly in the province of Quebec, but all the material thus accumulated was subsequently destroyed by fire, prior to his death which occurred at Montreal in 1820. The botanic collections of Dr. A. F. HOLMES, TITUS SMITH, JOHN GOLDIE, DAVID DOUGLAS (1824), BACHELOT DE LA PYLAIE stimulated great scientific activity and for the first time the names of W. J. and J. D. HOOKER, as also of ROBERT BROWN, become permanently connected with the history of Canadian botany. Within the same period was a somewhat remarkable advance in botanic science in the United States the results of which was an important influence exerted on Canadian botany. In 1828 NUTTALL's Genera of North American plants appeared to be followed in 1842 by his important supplement to the work of the younger MICHAUX on the North American Sylva. The names of W. P. BARTON, JOHN TORREY, PARRY are incidentally associated with the northern flora. In 1840 WILLIAM JACKSON HOOKER published his great work Flora Boreali-Americana and in it recorded all the knowledge of species and their distribution obtained by the early travellers and explorers, such as ROSS, FRANKLIN, BEECHY and the officers of the Hudson Bay Company. TORREY and GRAY in the same year published their work on the Flora of North America which included the Polypetalae only. Three years later the Gamopetalae to the end of the Compositae was published by the same authors

and finally in 1878, ASA GRAY published the remaining part of the Gamopetalae. For notices of Newfoundland plants, besides the volumes mentioned above, we are indebted to Dr. JOHN BELL who published a list of plants collected by him on the west coast of the island in 1867, which plants are in the herbarium of McGill University. WAGHORNE (1893—95) published a paper on the Flora of Newfoundland, Labrador and Saint Pierre et Miquelon.

In addition to the last mentioned paper, the flora of Labrador is represented by a number of publications. MEYER in 1830 issued his De plantis labradoricis, at Leipzig. JOHN RICHARDSON published in the Annals of the Canadian Botanical Society a list of plants collected on the island of Anticosti and the coast of Labrador. BUTLER in the Canadian Naturalist for September 1870 has an article on Labrador plants. ROBERT BELL comes next with a paper published in the Geological and Natural History Survey of Canada, entitled Observations on the Geology, Mineralogy, Zoology and Botany of the Labrador Coast, Hudson's Strait and Bay (1884). JOSEPH F. JAMES published the same year his Flora of Labrador, and the next year MACOUN in the Annual Report of the Geological and Natural History Survey of Canada his list of plants known to occur in the Labrador peninsula. Several other papers deal with the flora of Labrador, but two only of these can be mentioned here, namely, the chapter on botany in PACKARD's book, entitled the Labrador Coast, a Journal of Two Summer Cruises to that Region (New York 1891) and the report of the BROWN-HARVARD expeditions to Labrador in 1900, where the botanic results of the expedition are given.

Our knowledge of the Nova Scotian flora is derived chiefly from a list published in the Proceedings and Transactions of the Nova Scotian Institute of Natural Science for 1875—76 and to a Catalogue of the Flora of Nova Scotia by A. W. H. LINDSAY with the ferns contributed by Rev. E. BALL and the fungi by J. SOMMERS, published in the fourth volume of the afore mentioned proceedings.

The New Brunswick flora is represented by a Catalogue of New Brunswick plants published in the years 1878—79 by the Rev. JAMES FOWLER, professor of natural history, Queen's College, Kingston, Ontario. The Bulletin of the Natural History of New Brunswick (1882—83) contains additional notices both of species and localities, while in the Botanical Gazette for 1885 appears an article entitled Botanical Features of New Brunswick by G. U. HAYS. The same botanists published an account of the marine algae of New Brunswick in the fifth volume of the Proceedings and Transactions of the Royal Society of Canada and later lists of fungi and mosses noticed in the bibliography. Rev. JAMES FOWLER contributed to the last mentioned journal, an account of arctic plants growing in Brunswick and an additional paper on the same subject published in the sixth volume. Prof. L. W. BAILEY in the first volume new series of the Canadian Naturalist furnishes some notes on the geology and botany of New Brunswick and Prof. W. F. GANONG studying the flora from the ecologic side is the author of a number of important papers entitled

On Raised Peat Bogs, On Halophytic Colonies in the Interior of New Brunswick, On the Natural History and Physiography of New Brunswick, and finally in 1903 in the Botanical Gazette, a series of articles on the Vegetation of the Bay of Fundy Salt and Diked Marshes.

Our knowledge of the Quebec flora is obtained from the following sources: a Catalogue of the Plants collected by Dr. ANDREW HOLMES in the Vicinity of Montreal about the Year *1821*. These plants are in the herbarium of McGill University. Dr. THOMAS published a list of plants growing at Rivière du Loup and on the Island of Orleans. L'Abbé OVIDE BRUNET's catalogue published by the author in 1865 and distributed to friends, gave all the Canadian plants in the herbarium of Laval University, Quebec. W. S. M. D'URBAN collected plants in the year 1858 in the counties of Argenteuil and Ottawa and published the list in the Canadian Naturalist and Geologist for 1861. A few additions were made in the Canadian Flora (Flore Canadienne) published by L'Abbé PROVANCHER and by Dr. MACLAGAN, who collected near Montreal, and at a few other localities in the province of Quebec. The results of MACOUN's exploration in Gaspé are included, as well, as notes obtained from an examination of the various collections in McGill University an the herbarium of the Natural History Society of Montreal. This historic account of Quebec is nearly complete, if we mention the following papers, viz., J. G. JACK, Native Trees and Shrubs about Montreal, Canada; The Flora of Montreal Island by Rev. ROBERT CAMPBELL; Some Statistical Features of the Flora of Ontario and Quebec by A. T. DRUMMOND and published in the Canadian Naturalist (new ser. III, 29); Alpine Flora of the Province of Quebec by J. A. ALLEN; Notes on the Flora of Cacouna, P. Q. by Prof. D. P. PENHALLOW. — Ontario has been pretty thoroughly worked in almost every district. The eastern part by Mr. JAMES FLETCHER and Mr. R. B. WHYTE of the Ottawa Field Naturalists' Club, and by B. BILLINGS, Esq. in the neighborhood of Prescott and Brockville. JOHN MACOUN'S explorations include the Counties of Prince Edward, Addington, Hastings, Northumberland, Peterboro and Victoria in the central district; the vicinity of Toronto, the Niagara peninsula, the country along Lake Erie, the north shore of Lake Superior, and the country from Thunder Bay to Manitoba. The neighborhood of Hamilton has been well explored, by JUDGE LOGIE and J. M. BUCHAN. The district about London has been examined carefully by WILLIAM SAUNDERS and THOMAS BURGESS, who has also explored from Niagara Falls to Muskoka and Parry Sound. JOHN BELL published a list of Manitoulin Island plants.

Dr. ROBERT BELL has collected in the country north of Lake Superior, along the shores of Lake Huron and in the country extending northward to James' Bay along the east coast of Hudson's Bay, and in the valleys of the Nelson and Churchill rivers and the intervening district. WARBURTON PIKE in his book The Barren Ground of Northern Canada (London 1891) makes frequent mention of the plants of that region and still later EDWARD A. PREBLE unter the auspices of the Division of Biological Survey, U. S. Depart-

ment of Agriculture gives an account of a biologic investigation of the Hudson Bay region. The Ottawa Naturalist 1899 contains an article by M. L. FERNALD, on the Northwest Shore of Hudson Bay, and a few years prior to this (1895), TYRREL published in the Geographical Journal an account of a second expedition through the Barren Lands of Canada.

The great plains between Manitoba and the Rocky Mountains have been pretty thoroughly examined. The collection made by Dr. G. M. DAWSON, while geologist and naturalist to the boundary commission, embraces the whole flora of the 49th parallel from the Lake of the Woods to the Rocky Mountains. During the summers of 1872, 1875, 1879, 1880, 1881, JOHN MACOUN made extensive journeys through both the prairie region and the wooded country to the north, as far as latitude 59°, including the whole length of the great Peace River. M. BOURGEAU, botanist to Captain PALLISER'S expedition in 1857—58, made numerous traverses of the country bordering on the Saskatchewan and southward. DOUGLAS and DRUMMOND explored the whole country from the Red and Assiniboine rivers to the Rocky Mountains. The former passed across the Rocky Mountains by the Athabasca Pass and examined the entire length of the valley of the Columbia, while the latter collected in the main range of the Rocky Mountains between latitude 52° and 56°, and particularly in that part about the head of the Smoky River, a tributary of the Peace. Sir JOHN RICHARDSON and other arctic explorers have noted and collected the plants of the wooded country from Hudson Bay to the Arctic Sea, its coasts and islands, including the country north of the Saskatchewan River and the whole valley of the Mackenzie River.

The flora of the Rocky Mountain region proper is still imperfectly known. Dr. G. M. DAWSON examined the region in the vicinity of South Kootanie Pass, near the 49th parallel, and traversed the mountains by Pine Pass in latitude 55°. In September 1879, JOHN MACOUN ascended the Bow River Pass for a few miles, and obtained some knowledge of its alpine flora. BOURGEAU also spent some time in August 1858 in the Bow River Pass and on the adjacent mountains and made extensive collections. During his explorations with Douglas, DRUMMOND spent a whole summer in the mountains. — In 1875 JOHN MACOUN was again in the mountains, ascending the Peace River Pass and Mount Selwyn at its western end. Rev. ROBERT CAMPBELL published in the Canadian Record of Science a paper on the flora of the Rocky Mountains. Quite recently, Dr. CHAS. SCHÄFFER and Mrs. SCHÄFFER of Philadelphia have spent several summers in the Selkirk mountains collecting and photographing the plants. During the months of July and August 1903, 1904 Miss EDITH FARR of the University of Pennsylvania collected plants in the neighborhood of Banff, Field, Glacier, lakes Agnes and Louise and these plants are preserved in the herbarium of the University at Philadelphia. Dr. CHARLES H. SHAW of Ursinus College, Collegeville, Pa., and STEWARDSON BROWN of Philadelphia made some extended tours through these mountains and rich

British Columbia also still requires much attention. Besides the early explorers mentioned by Hooker, JOHN MACOUN during the early part of 1875 made collections of plants on Vancouver Island and in the valley of the Fraser River from the coast to Fort McLeod at the western base of the Rocky Mountains in latitude 55°. G. M. DAWSON collected on Vancouver Island in the valley of the Fraser in the country lying west of it to the coast ranges in 1875—76, and during the summer of 1879, a traverse was made to the Rocky mountains by way of the Skeena River. The results of these and other expeditions are given in the Reports of the Geological and Natural History Survey of Canada for 1875—76, 1876—77, 1879—80, 1882—84. JOHN MACOUN contributed to Garden and Forest in 1888 an article on the Forests of Vancouver Island and to the same periodical an account of the mountain forests of that island. M. LAPATECKI contributed an article to the West American Scientist in 1899 on the Trees of British Columbia, and GEO. M. DAWSON to the Canadian Naturalist notes on the distribution of some of the more important trees of British Columbia with maps. A. J. HILL in 1880—82 investigated the flora of the Fraser and Thompson rivers. WILFRED H. OSGOOD, under the auspices of the Division of Biological Survey, United States Department of Agriculture, gives a description in bulletin number 21 of the natural history of the Queen Charlotte islands and of their flora. The algae of the coast are adequately treated in a monograph by WILLIAM A. SETCHELL and N. L. GARDNER entitled Algae of Northwestern America issued in the University of California publications on botany, 1903. S. A. SKINNER contributes to our knowledge of the Algae of Port Renfrew in Minnesota Botanical Studies (third series Part II, 145).

The Flora of Alaska has been investigated by a number of botanists. J. T. ROTHROCK in the Report of the Smithsonian Institution for 1867 published his Flora of Alaska. JOHN MUIR is the author of the pages on botany in the report of the cruise of the Revenue Steamer Corwin in Alaska and the northwest Arctic Ocean in 1881 (Washington 1883). THOMAS MEEHAN in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1884 published a Catalogue of Plants collected in July 1883 during an excursion along the Pacific coast in southeastern Alaska. In the Annual Report of the Geological and Natural History Survey of Canada (1887—88) is published an account of the flora of Chilkoot Pass and in the first and third appendices of that report appear accounts of the vegetation of the Yukon district. GEORGE M. DAWSON has an article in Garden and Forest for 1888 on the forest trees of the far northwest and THOMAS MEEHAN in Gardener's Chronicle (1891, p. 732) on the Alaskan forests. GRACE E. COOLEY gives a list of plants collected in Alaska and Nanaimo 1891 in Bulletin of the Torrey Botanical Club. A list of plants collected near Muir Glacier is given in the National Geographic Magazine (1892, p. 79) by W. W. ROWLEE. FREDERICK V. COVILLE and FREDERICK FUNSTON describe the Botany of Yakutat Bay, Alaska in the third volume of Contributions from the U. S. National Herbarium (1895, p. 325).

R. S. WILLIAMS contributes to the Plant World, Botanical Notes on the Way to Dawson, in 1899 and J. B. FLETT in the fourth volume of the same journal Notes on the Flora about Nome City (1900). The two sumptuous volumes published as the Results of the HARRIMAN Alaska Expedition issued with the cooperation of the Washington Academy of Sciences contain several chapters on the flora of the region visited, particularly one chapter on the forests of Alaska by BERNARD E. FERNOW, who also furnishes an account of these forests to the eighth volume of Forestry and Irrigation (06).

No. 19, North American Fauna (1900) contains an account of the flora of the Yukon River Valley, as the results of a biologic reconnoissance of the river by WILFRED H. OSGOOD, who the next year 1901 contributes to number 21, North American Fauna, a description of the natural history of the Cook Inlet region, including a short account of the flora.

The flora of the Pribilof islands in Bering Sea has been investigated by JAMES MACOUN (1893), C. HART MERRIAM (1892). A paper by JAMES M. MACOUN, published as a part of the report on the furseals and furseal islands (Washington 1899), gives a list of the plants known to grow on the islands.

## II. New England.

No one region in North America has been more carefully studied botanically than New England. Many books and papers have at various times been published on its flora, and it is, therefore, incumbent on the writer to refer to only the most important that have appeared.

The first serious attempt to describe the natural products of New England was made by JOHN JOSSELYN in two volumes entitled, "New England Rarities discovered in Birds, Beasts, Fishes, Serpants and Plants of that Country, (London 1672)". However, Dr. MANASSEH CUTLER may be called the first New England botanist. In 1785 in the first volume of the Memoirs of the American Academy of Arts and Sciences was printed the chief published result of this botanist's studies in a paper entitled "Account of some of the Vegetable Productions growing in this part of America, botanically arranged". In July 1784, CUTLER was a member of the first party to ascend the White Mountains for scientific observation; and he repeated the trip twenty years after. Dr. BENJAMIN WATERHOUSE was a botanist of note, professor of the theory and practice of the physic in the University at Cambridge, Mass., and his botanic lectures were printed in the Monthly Anthology from 1804 to 1808, and in 1811, they were first published at Boston in a volume entitled The Botanist. In 1805, the botanic garden at Cambridge was established and WILLIAM DANDRIDGE PECK became the first incumbent of the chair of natural history. He was succeeded by THOMAS NUTTALL, who remained as curator of the garden until 1828. JACOB BIGELOW, a contemporary of Peck and Nuttall, published his Florula Bostoniensis in 1814. The American Medical Botany was published in three volumes between 1817 and 1820 and was long the

standard authority on officinal plants. AMOS EATON was the author of various text-books and of the most widely used Manual of Botany which appeared about 1814. The last edition of this work called North American Botany was printed in 1840.

Passing over the names of CHESTER DEWEY, the brothers BOOTT interested in the study of the carices, we come to EDWARD HITCHCOCK, professor of chemistry and natural history in Amherst College. He published in 1829, a Catalogue of Plants growing within twenty miles of Amherst College. He also prepared the first Report on the Animals and Plants of Massachusetts. GEORGE B. EMERSON must be mentioned next. To the preparation of his report on the Trees and Shrubs growing naturally in the forests of Massachusetts, he devoted all his leisure for nine years. It was published at Boston in 1846 and a beautiful second edition with colored plates, followed in 1875. The names of WILLIAM OAKES and CHARLES PICKERING author of the Chronological History of Plants, Man's Record of his own Existence, are inseparably connected with the early history of New England botany. In 1833, Harvard College received by the will of Dr. JOSHUA FISHER, an endowment to establish a Fisher-professorship of natural history. This chair was offered in 1842 to ASA GRAY and accepted by him. His first book published when he was twenty-six years old was the Elements of Botany. In 1842 appeared the Botanical Text-book, and in 1848 the first edition of the Manual of Botany, the fifth edition published in 1867, the sixth in 1890 after the distinguished author's death, and the last edition in 1908. GRAY's chef d'œuvre, the Synoptical Flora of North America appeared in several volumes, as follows: Volume II Part I Gamopetalae after Compositae 1878; Volume 1 Part II Caprifoliaceae to Compositae 1884; Volume I Part I Polypetalae to Frankeniaceae 1895.

The name of CHARLES WRIGHT is associated with that of Asa Gray. Wright spent some years after his graduation in 1835 in the exploration of Texas, and the fruit of his labors appeared in Plantae Wrightianae by Gray. SERENO WATSON, an associate of Asa Gray in botanic work, accompanied KING's exploring expeditions from 1867 to 1871. The resulting volume the first (1876) of the Botany of California showed his grasp of the subject so clearly that he was appointed curator of the Gray-Herbarium in 1874. The second volume appeared in 1880. SERENO WATSON is also the author of an important work entitled Bibliographical Index to North American Botany (1878).

The first systematic account of American Algae is by an Irishman WILLIAM HENRY HARVEY. About 1849 he spent considerable time in New England and issued a work in three parts the Nereis Boreali-Americana. EDWARD TUCKERMAN engaged himself in the study of lichens published Genera Lichenum: an Arrangement of North American Lichens 1872, and he also found time to issue an elaboration of HITCHCOCK's catalogue of plants growing within twenty miles of Amherst College. STEPHEN T. OLNEY of Rhode Island published a Catalogue of Rhode Island Plants and a few years before his death in 1873 his Algae Rhodiacae. THOMAS P. JAMES, a resident of Cambridge, with LEO

LESQUEREUX issued in 1884 a Manual of the Mosses of North America, which has never been replaced by a later work. DANIEL CADY EATON was graduated from Yale in 1857 and spent his life there as professor of botany. He elaborated the pages on the ferns in the several editions of GRAY's Manual and published in addition, Ferns of the Mexican Boundary in Mexican Boundary Survey (1857); Ferns of North America illustrated with colored plates by J. H. EMERTON and C. E. FAXON. CHARLES J. SPRAGUE (1856—58) published several papers on New England mycology. ALEX. F. KEMP studied the seaweeds, and his paper entitled on the Shore Zones and Limits of Marine Algae on the N. E. Coast of the United States was printed in the Canadian Naturalist and Geologist in 1862. WILLIAM G. FARLOW, pursuing the same line of research, published two papers on seaweeds under the auspices of the United States Fish Commission. The last one, still in use, entitled Marine Algae of the New England and Adjacent Coast, appeared in 1879. FREDERICK L. SARGENT printed in 1886 a Guide to the Principal Orders of Cryptogams and the Commoner and more easily distinguished New England Genera.

Passing by the long list of local floras, lists and notices of plants which have appeared on the New England flora, mention should be made of the Flora of Essex County, Massachusetts 1880 by JOHN ROBINSON; a Catalogue of Plants growing without cultivation in the County of Nantucket, Mass. 1888 by MARIA L. OWEN; Catalogue of all Phaenogamous Plants at present known to grow without Cultivation in the State of Connecticut (1851) by JAMES N. BISHOP; The Portland Catalogue of Maine Plants (first edition 1868; second edition 1892); a Preliminary Catalogue of the Plants growing on Mount Desert and the Adjacent Islands by EDWARD L. RAND and JOHN H. REDFIELD 1894.

Flora of Vermont. A List of the Fern and Seed Plants growing without Cultivation in Vermont prepared by EZRA BRAINERD, L. R. JONES and W. W. EGGLESTON, committee for the Vermont Botanical Club 1900; Flora of the Town of Southington, Conn. and its Vicinity by CHARLES H. BISSELL and LUMAN ANDREWS 1902; Catalogue of the Plants of New Hampshire by WM. F. FLINT 1874. Plants of Rhode Island being an Enumeration of Plants growing without Cultivation in the State of Rhode Island by JAMES L. BENNETT appeared in 1888, as a publication of the Providence-Franklin-Society; List of Marine Algae collected near Eastport; Me. by D. C. EATON (New Haven 1873); Desmids of Maine by WILLIAM WEST 1888 and Fresh Water Algae of Maine by F. L. HARVEY in 1889.

The Silva of North America, a Description of the Trees which grow naturally in North America, by CHARLES SPRAGUE SARGENT, Director of the Arnold Arboretum near Boston, Mass. is a monumental work on American botany issued in twelve sumptuous volumes between 1891 and 1898. The beautiful drawings reproduced in the work are by C. E. FAXON. Prof. SARGENT is also editor of the Scientific Papers of Asa Gray in two volumes, published in 1889; author of The Woods of the United States with an Account of their

*Structure, Qualities, and Uses* 1885 and *Report on the Forests of North America*, issued as a volume of the Tenth Census of the United States in 1884 with numerous maps. In Rhodora (1903), the organ of the New England Botanical Club, Prof. SARGENT has contributed a series of five articles on Recently Recognized Species of *Crataegus* in Eastern Canada and New England. Aside from Prof. Sargent's Silva, perhaps his most valuable work, is his Manual of the Trees of North America (exclusive of Mexico) a book of 826 pages, issued in 1905.

New England botany has been enriched also by the contributions of B. L. ROBINSON, M. L. FERNALD and JESSE M. GREENMAN, who have done much to make the flora of the region known, beside working upon the collection of Mexican and Central American plants forwarded to the Gray Herbarium by CYRUS G. PRINGLE and other botanists for identification.

Mention has not been made of the collectors, who have done so much to forward our knowledge of New England plants. The vegetation of the White Mountains has been investigated by EDWIN FAXON, C. H. HITCHCOCK, CYRUS G. PRINGLE, FULLER, ENDICOTT, HUNT and DAVIS, J. W. CHICKERING, W. G. FARLOW and B. F. ROBINSON. FREDERICK W. BATCHELDER has printed a *Preliminary List of Plants growing without Cultivation in the Vicinity of* Manchester, New Hampshire 1899. Our knowledge of the flora of Mt. Katahdin is due to the efforts of J. W. BAILEY, F. LAMSON-SCRIBNER, CHARLES E. HAMLIN, GEORGE R. KENNEDY, MERRITT L. FERNALD, J. FRANKLIN COLLINS, EMILE F. WILLIAMS, JOSEPH R. CHURCHILL, J. W. HARSHBERGER, LE ROY H. HARVEY and GEORGE THURBER. WILLIAM GILSON FARLOW has contributed articles to various scientific journals on the fungi of the region and other botanists have furnished articles which are now counted by the hundreds. An enumeration of the various papers that have appeared is given by MARY A. DAY in Rhodora under the caption the Local Floras of New England, and these series of articles must be referred to, as also a List of State and Local Floras of the United States and British America by N. L. BRITTON in the Annals of the New York Academy of Sciences 1890 page 237 to 300, for bibliographic details.

Early in his botanic work, about 1835, Dr. ASA GRAY began his herbarium [1]. His own collecting was largely done in the lake-region of western central New York, the Southern Alleghanies, the central Rocky Mountains, Mexico and California. Associated with Dr. JOHN TORREY from 1838 to 1843 in the preparation of the Flora of North America. Dr. Gray received duplicate types of nearly all the plants therein described. Soon after began the notable series of trans-continental surveys. During this epoch extending from FREMONT's expedition in 1842 to the natural history survey of California, Dr. GRAY's eminence in American botany attracted to him an extraordinary wealth of botanic material. The collections of the Pacific Exploring Expedition, of CHARLES WRIGHT in Texas, New Mexico, Arizona, Cuba and Nicaragua,

1) Rhodora September 1901 page 243. Mary A. Day: III Harvard University. Gray Herbarium.

of AUGUST FENDLER in New Mexico, Venezuela and Trinidad, of Dr. GEORGE THURBER on the Mexican boundary, of Messrs. BREWER, BOLANDER and others in California, of Dr. SERENO WATSON in the Great Basin, and of Dr. ROTHROCK in Arizona merit particular mention on account of their size and importance. — In 1864, Dr. GRAY presented his herbarium and valuable library to Harvard College. From the early seventies until the end of his life Dr. GRAY was engaged in the preparation of the Synoptical Flora and his notes made then on the herbarium sheets adds to their value. His studies on the Mexican flora upon the basis of the rich collections of GREGG, WRIGHT, SCHAFFNER, PARRY, PALMER and PRINGLE are represented by notes made on the collections in the Gray Herbarium.

In 1870 Dr. SERENO WATSON who had been engaged at the Gray Herbarium in the identification of the material from the Clarence King Exploration of the 40th parallel, was made assistant and later in 1880 Curator. After the death of Dr. Watson in 1892, the present curator Dr. B. L. ROBINSON was appointed.

Among the most noteworthy collections which have been incorporated in the Gray Herbarium are the herbaria of JACQUES GAY, G. CURLING JOAD, JOHN BALL, of WILLIAM BOOTT, containing a wealth of New England material, chiefly from the suburbs of Boston, the White Mountains and Vermont, and the Compositae from the herbarium of Dr. F. W. KLATT of Hamburg.

The cryptogamic herbarium of Harvard University contains the collection of fungi of the late Rev. M. A. CURTIS, the lichens of EDWARD TUCKERMAN purchased in 1888 and those of C. J. SPRAGUE, J. MUELLER and W. G. FARLOW.

The algae are represented by the sets of C. L. Anderson, G. J. AGARDH, J. E. ARESCHOUG, E. A. BATTERS, ED. BORNET, C. FLAHAULT, M. FOSLIE, E. M. HOLMES, F. HAUCK, P. HENNINGS, F. J. KJELLMAN, M. A. LE JOLIS, F. VON MUELLER, T. REINBOLD, J. REINKE, L. K. ROSENVINGE, E. P. WRIGHT and others. The mosses are represented by the herbarium of W. S. SULLIVANT, the large collections of THOMAS P. JAMES and THOMAS TAYLOR.

## III. Middle Atlantic States.

The early history of botany in New York State gathers about the name of JOHN TORREY. However prior to his active labors, JACOB GREEN issued a Catalogue of Plants indigenous to the State of New York in 1814 and in 1829 JAMES MACAULEY, Trees, Shrubs and Plants of New York. JOHN TORREY was early associated with Major LE CONTE, with DAVID HOSACK, who during Torrey's youth was engaged in the development of the Elgin Botanic Garden, where TORREY studied under the direction of that eminent physician and naturalist. His flora of the Northern and Middle States, or Systematic Arrangement and Description of all the plants heretofore discovered north of Virginia was published in 1824 and later his Compendium of the Flora of the Northern and Middle States in 1826. Appointed botanist of the

Geological Survey of New York at its organization in 1836, he brought together the material which was issued in 1843, as a Flora of the State of New York in two large quarto volumes illustrated by 161 plates. Shortly after the publication of the Botany of the Mexican Boundary in 1859, DR. TORREY transferred his herbarium and botanic library to Columbia College, where it forms the nucleus of the collections now gathered together in the New York Botanic Museum at Bronx Park. The Flora of North America containing Descriptions of all Plants north of Mexico by TORREY and GRAY in two volumes appeared in the period from 1838 to 1843. The TORREY Botanical Club organized in 1873 has been a constant stimulus to botanic work in New York City and neighborhood. One of the most valued results of its labors has been the work of individual members on the local flora. Catalogues prepared by members, later than the Catalogue by Torrey in 1817, where those on Staten Island by N. L. BRITTON and ARTHUR HOLLICK; Stissing Mountain by LYMAN O. HOYSRADT; on West Chester County by O. R. WILLIS; on Manhattan Island by O. W. MORRIS; on Central Park by E. A. DAY; on Long Island by S. E. JELLIFFE extending the earlier partial lists of E. R. MILLER, HENRI W. YOUNG and others. Most valuable work contributory to the New York local flora was done by W. H. LEGGETT, C. F. AUSTIN, T. F. ALLEN, H. SCHRENK in earlier years and in recent years by Rev. MR. LIGHTHIPE, Mrs. E. G. BRITTON, MISS SANIAL, E. P. BICKNELL and N. L. BRITTON. The Preliminary Catalogue of Anthophyta and Pteridophyta growing within 100 miles of New York was a result of the labors of N. L. BRITTON, E. E. STEARNS and JULIUS POGGENBURG. In addition to the publications issued under the auspices of the Torrey Club should be mentioned PAINES Catalogue of Plants found in Oneida County 1864; the Cayuga Flora by WM. R. DUDLEY 1886; the Plants of Buffalo and its Vicinity (1882) by DAVID F. DAY; the Chatauqua Flora by EDWARD S. BURGESS in 1877; Flora of the Upper Susquehanna by WILLARD N. CLUTE and later 1903 by FRANK E. FENNO for the same region; Plants of Monroe County, New York 1896 by FLORENCE BECKWITH and MARY E. MACAULEY; Plants of the Summit of Mt. Marcy published in Bulletin of New York State Museum for 1899 by CHARLES H. PECK, and Plants of North Elba in the same periodical for 1899 by the same botanist. BRITTON and BROWN's Illustrated Flora appeared in 1896, BRITTON's Manual in 1901 and BRITTON and SHAFER's North American Trees in 1908.

The botanic staffs of Columbia University and the recently organized New York Botanic Garden and Museum in Bronx Park have within the past few years shown unusual vigor in the pursuit of botanic knowledge under the direction of NATHANIEL L. BRITTON and LUCIEN M. UNDERWOOD, a large botanic establishment has been formed, vast collections of plants from all parts of America and the world have been gathered and expeditions in search of botanic material have been in the field under the auspices of the New York Botanic Garden. MARSHALL A. HOWE has devoted his attention to hepatic mosses and seaweeds, Mrs. E. G. BRITTON and A. J. GROUT to true mosses,

F. S. EARLE to the fungi, N. L. BRITTON to the flowering plants of the northern states, West Indies, JOHN K. SMALL to the flowering plants of the southern states. PER AXEL RYDBERG has devoted himself to the Rocky Mountain flora, LUCIEN M. UNDERWOOD to the ferns, while FRANCIS E. LLOYD, DANIEL T. MACDOUGAL, CARLETON C. CURTIS devote themselves to the morpho-physiology of plants. The Bulletin of the Torrey Botanical Club first issued in 1870, has appeared regularly ever since; it was long under the editorship of W. H. LEGGETT, later of W. R. GERARD, afterward of Dr. and MRS. BRITTON, LUCIEN M. UNDERWOOD and now in charge of JOHN H. BARNHART. Its influence has been felt in Europe and all parts of the American continents. The work of these botanists and others will appear in North American Flora, Descriptions of the wild plants of North America, including Greenland, the West Indies and Central America (now in course of publication).

The flora of New Jersey has received attention from both the botanists of New York City and of Philadelphia. ARTHUR HOLLICK, L. H. LIGHTHIPE, N. L. BRITTON of the New York Club have investigated it, while JOHN M. MAISCH, I. C. MARTINDALE, JOHN H. REDFIELD, ISAAC BURK, J. BERNARD BRINTON, JOSEPH CRAWFORD, STEWARDSON BROWN, BENJAMIN HERITAGE, USELMA C. SMITH, are Philadelphians that have made collections in New Jersey. P. D. KNIESKERN published in 1857 a Catalogue of Plants growing without Cultivation in the Counties of Monmouth and Ocean in the State of New Jersey and SAMUEL ASHMEAD in 1857, a List of Plants and a Catalogue of Marine Algae collected on the Coast of Egg Harbor. ISAAC C. MARTINDALE contributed to the memoirs of the Torrey Botanical Club a monograph on the marine algae of the New Jersey coast and adjacent waters of Staten Island, 1889. MARY TREAT of Vineland has studied the flora from the standpoint of a nature lover and has contributed observations of value to botanic science. J. W. HARSHBERGER has written on the Strand Flora of New Jersey in two papers 1900 and 1902. A Preliminary Catalogue of the Flora of New Jersey, issued by the Geological Survey, was printed at New Brunswick in 1881 and in the final report of the State Geologist, volume II (1889), appears the Catalogue of Plants found in New Jersey by N. L. BRITTON (pages 27—642). Both of these publications were preceded by Catalogue of Plants growing without Cultivation in the State of New Jersey by O. R. WILLIS 1874 with a revised edition in 1878.

The history of botany in Pennsylvania may be said to commence with the establishment in 1694 of a garden at the Hermitage on the lower Wissahickon Creek by the German Pietists, presided over by KELPIUS, where medicinal plants were raised for use and study. In 1739 was published at Leyden in Holland an essay entitled Experimenta et Meletemata Plantarum generatione by the Governor of Pennsylvania JAMES LOGAN. This may be said to be the first work issued by a Philadelphia botanist. In the year 1748, PETER KALM, a pupil of LINNAEUS, visited Pennsylvania and spent three years in exploring America, and in 1753—61 published En Resa til Norra America

in three volumes, translated into German in 1754—64. Passing by JOHN BARTRAM, who established the second botanic garden in America, and ADAM KUHN, professor of botany in the University of Pennsylvania, we come to HUMPHREY MARSHALL, author of Arbustum Americanum the American Grove, or an alphabetical Catalogue of Forest Trees and Shrubs, natives of the American United States (Philadelphia 1785).

In 1791 WILLIAM BARTRAM's Travels through South Carolina, Georgia, East and West Florida appeared and in 1801 ANDRÉ MICHAUX's Oaks of North America. Two years later in 1803, the first elementary work on botany by BENJAMIN SMITH BARTON was published in Philadelphia. F. ANDRÉ MICHAUX in 1810 issued his history of the forest trees of North America (Histoire des Arbres Forestières de l'Amerique Septentrionale) with colored plates. A catalogue of the native and naturalized plants of North America was published by MUHLENBERG at Lancaster in 1813. Later FREDERICK PURSH published in London in 1814 his comprehensive work Flora Americae Septentrionalis. Arranged according to the Linnaean system, there appeared in 1818 in two volumes WILLIAM P. C. BARTON's Compendium Florae Philadelphicae. Botanic works and papers began now to multiply and in 1818 THOMAS NUTTALL issued his Genera of North American Plants.

In 1826 in conjunction with some of his intimate friends, WILLIAM DARLINGTON of West Chester assisted in organizing the Chester County Cabinet of Natural Science and in the same year published Florula Cestrica. This paved the way for a large and more comprehensive manual of the botany of Chester County, which appeared in 1837 under title of Flora Cestrica. A third edition of this book appeared in 1853. The study of the cryptogams was not neglected, for LEWIS D. DE SCHWEINITZ published in 1831, a synopsis of North American fungi, *Synopsis Fungorum in America Boreali Media Digentium*. About the same time ELIAS DURAND contributed several botanic papers to the Journal of the Academy of Natural Sciences namely, descriptions of HEERMANN's and PRATTEN's collections. In 1899 appeared an historic account of the botany of the region in the Botanists of Philadelphia and their Work by JOHN W. HARSHBERGER.

The University of Pennsylvania and the Academy of Natural Sciences of Philadelphia may be looked upon as seats of botanic learning for Pennsylvania and for the adjoining region. The history of botany at the University is somewhat as follows ADAM KUHN a pupil of LINNAEUS was the first professor of botany being appointed in the year 1768. BENJAMIN SMITH BARTON occupied the chair of materia medica and botany from about 1800 to 1813. He was succeeded by WILLIAM P. C. BARTON in 1816 who lectured until about 1822; the faculty of natural history being abolished in 1828. In 1829 SOLOMON W. CONRAD was elected botanist and served until the time of his death in 1831. Later in 1835, GEORGE B. WOOD was elected to the chair of materia medica and was succeeded by his nephew HORATIO C. WOOD, who occupied the chair of botany until 1876 when JOSEPH T. ROTHROCK was

elected to fill the vacancy caused by Dr. WOOD accepting the chair of materia medica and therapeutics. In 1884, the School of Biology was opened through the liberality of Dr. HORACE JAYNE and with Dr. ROTHROCK was associated WILLIAM P. WILSON, who was appointed professor of the anatomy and physiology of plants. Later upon the resignation of Dr. WILSON, JOHN M. MACFARLANE was made professor of botany and director of the botanic garden and with them have been associated in the teaching JOHN W. HARSHBERGER, JESSE M. GREENMAN, HOBART C. PORTER, ORVILLE P. PHILLIPS, HENRY S. CONARD, LOUIS KRAUTTER. The herbarium of the department of botany began with the collections of ISAAC BURK, as a nucleus, to which have been added subsequently the herbaria of AUBREY H. SMITH, JOSEPH LEIDY, J. BERNARD BRINTON, the fern collections of JOHN W. ECKFELDT, the collections of C. G. PRINGLE, J. W. HARSHBERGER, J. T. ROTHROCK, J. M. MACFARLANE, EDITH M. FARR, H. S. CONARD, LOUIS KRAUTTER and others.

The Academy of Natural Sciences of Philadelphia was founded March 12th, 1812 and from the outset the department of botany received attention. The first contribution to the Academy's herbarium consisted of a collection of plants made in the environs of Paris and presented by NICHOLAS S. PARMENTIER. During the years which followed, this nucleus received constant accretions and the names of COLLINS, ELLIOTT, PURSH, BALDWIN, LE CONTE, CONRAD, NUTTALL, TORREY and PICKERING are inscribed on many of the tickets attached to the plant sheets. In 1834, the Academy received by bequest the collections made by LEWIS DAVID DE SCHWEINITZ. Other valuable contributions followed among which may be specified the POITEAU collection of Santo Domingo plants, Chilian plants from STILES and RUSCHENBERGER; NUTTALL's collections made in his expeditions to Arkansas, Oregon and the Sandwich Islands; the ASHMEAD collection of marine algae; LESQUEREUX's collection of over 700 species of algae and a large collection of cryptogams from RAVENEL. More recent additions than the above consists of the herbaria of THOMAS G. LEA, JOSEPH CARSON, JOHN STUART MILL, the collections of CHARLES PICKERING, and the Mexican collections of PARRY, PALMER, PRINGLE, NELSON and ROSE. THE most important accession was the herbarium of CHARLES W. SHORT of Louisville, Kentucky. All these collections including those from North Pacific Survey by WILLIAM CANBY, from Alaska made by THOMAS MEEHAN, from the Yellowstone made by F. TWEEDY, from Tabasco and Chiapas, Mexico by ROVIROSA, from the West Indies by LEOPOLD KRUG, from Guatemala distributed by JOHN DONNELL SMITH, from the West Indies by ROTHROCK; from California by BRANDEGEE are valuable, because they represent type specimens. The cryptogamic collections include ELLIS' Centuries of North American Fungi, DRUMMOND's Mosses of the Rocky Mountains and British America; a set of fungi belonging to the late GEORGE MARTIN of West Chester and the lichen herbarium of JOHN W. ECKFELDT. New American collections are being constantly added to the Herbarium of the Academy of Natural Science, so it is kept up to date in almost every respect.

The later books on the flora of Pennsylvania may be said to begin with a Botany of Pennsylvania by CHAS. B. TREGO, which appeared in a Geography of Pennsylvania in 1843. HENRY R. NOLL's Flora of Pennsylvania and Botanist's Pocket Manual 1851. Journal of a Botanical Excursion in the Northeastern Parts of the States of Pennsylvania and New York during the year 1807 by FREDERICK PURSH was printed for the first time in 1869 and edited by THOMAS P. JAMES. In 1862 GEORGE SMITH published in the History of Delaware County, Penna. a description of the botany of the County. AUBREY H. SMITH issued a paper in 1867 on Colonies of Plants Observed near Philadelphia. THOMAS C. PORTER's Enumeration of the Indigenous Plants of Lancaster County, Pennsylvania was incorporated in MOMBERT's Authentic History (Lancaster 1869). A sketch of the botany of the state by the same botanist was published in WALLING and GRAY's New Topographical Atlas of the State of Pennsylvania (1872). A Catalogue of the Flowering Plants and Vascular Cryptogams found in and near Lackawanna and Wyoming Valleys by WILLIAM R. DUDLEY and CHARLES O. THURSTON appeared in 1892. THOS. C. PORTER published in 1898 in the Bulletin of the Torrey Botanical Club a description of the Flora of the Lower Susquehanna and issued privately in 1900 a small pamphlet entitled Rare Plants of Southeastern Pennsylvania. The ecologic aspect of the Pennsylvania flora has been presented in a paper by ALEXANDER MAC ELWEE, The Flora of the Edgehill Ridge near Willow Grave printed in the Proceedings of the Academy of Natural Sciences of Philadelphia and Flora of the Serpentine Barrens of Southeastern Pennsylvania by J. W. HARSHBERGER published in Science, and a Phytogeographic Sketch of extreme Southeastern Pennsylvania in the Bulletin of the Torrey Botanical Club for March 1904 by the same author. Finally in 1903 appeared Flora of Pennsylvania by THOMAS C. PORTER edited with the addition of Analytical Keys by JOHN K. SMALL. This work of three hundred and sixty two pages is a carefully annotated list of the plants of the state with notes on their geographic distribution by counties.

The flora of the State of Delaware is meagerly represented by published accounts. In 1860 EDWARD TATNALL published a Catalogue of the plants of New Castle County, and in 1902 in the Botanical Gazette, LETITIA M. SNOW, a paper entitled Some Notes on the Ecology of the Delaware Coast. The flora of this state has however, received attention from WILLIAM M. CANBY, a resident of Wilmington, who amassed a fine herbarium of the plants of his native state, as also various other parts of the United States and foreign countries. This herbarium was purchased by the College of Pharmacy of the City of New York and deposited in their building. J. T. PENNYPACKER has also actively collected plants in the State. —

The Southern United States have been carefully worked over by botanists usually non resident in that section, so that the stimulus which comes from the presence of coteries of botanists in the different cities and towns in the institutions of learning, which are not numerous and have been backward

in scientific progress, has been lacking. The result is, that there are few books dealing with the flora of the southern states and a paucity of local catalogues and lists. The writer believes that, in mentioning the following, very few important publications have been overlooked.

## IV. Southeastern States.

The first account of any importance that we have of Southern plants appears in the Natural History of Carolina by MARK CATESBY in two volumes (London 1731—43), followed by a book by J. BRICKELL. The Natural History of North Carolina (1737) where, pages 57—106, the vegetables of the country are discussed. These were proceeded by BANISTER'S Catalogus plantarum in Virginia observatarum 1688 and PETIVER'S Herbarium Virginianum 1707. Flora virginica (1739—43) by J. F. GRONOVIUS, WALTER'S Flora caroliniana (1788), WM. BARTRAM'S Travels through North and South Carolina, Georgia, East and West Florida 1791; J. L. E. W. SHECUT'S Flora carolinaeensis (Charlestown 1806) and BARTON'S Flora virginica (Philadelphia 1812), are among the most important early books on botany of the South. A catalogue of plants in the vicinity of Charlestown 1834 and one by GIBBER of plants of Columbia, South Carolina 1835, and catalogue of the native phaenogamous plants and ferns of Kentucky by SHORT (C. W.) PETER S. GRISWOLD 1833, occupy an intermediate position in point of time between the earlier books and the descriptive manuals. Until the appearance of STEPHEN ELLIOTT'S Botany of North Carolina and Georgia in two volumes 1821—24, there was no descriptive manual of the Southern States. Later this want was supplied by a Manual of Botany adapted to the Productions of the Southern States by JOHN DARBY published in 1814. This last work was supplemented by Darby's Botany of the Southern States in 1855.

Finally in 1865 appeared CHAPMAN'S Flora of the Southern States, which has appeared in several editions, the third one issued in 1897. During this time Rev. M. A. CURTIS published in 1867 a Catalogue of Indigenous and Naturalized Plants of North Carolina and in 1869 Resources of the Southern Fields and Forests was published by FRANCIS PEYRE PORCHER. A number of botanists have recently explored the southern states and as the result of their work have either published accounts of their labors, or have distributed their collections of plants to various botanic centres. Among these persons may be mentioned ASA GRAY, CHARLES S. SARGENT, A. H. CURTISS of Jacksonville, Florida, CHARLES MOHR of Alabama, ROLAND M. HARPER, JOHN K. SMALL, G. V. NASH, ANNA M. VAIL, THOMAS H. KEARNEY, H. J. WEBBER, J. M. MACFARLANE, LESTER F. WARD, C. D. BEADLE, of Biltmore, AUGUSTIN GATTINGER of Tennessee, GIFFORD PINCHOT, A. CUTHBERT of Georgia, C. F. MILLSPAUGH, A. M. HUGER of North Carolina, J. W. HARSHBERGER, FRANCIS E. LLOYD, S. M. TRACY, W. W. ASHE, W. C. COKER and F. E. BOYNTON. Reference will be made to their papers in the accompanying bibliography, but the following of special merit must be mentioned in this connection, viz., Flora

of West Virginia issued from the Field Columbian Museum Chicago 1896 by CHARLES F. MILLSPAUGH and LAWRENCE W. NUTTALL; Timber Trees and Forests of North Carolina by GIFFORD PINCHOT and W. W. Ashe 1897; the Plants covering of Ocracoke Island by THOMAS H. KEARNEY 1900; the Insular Flora of Mississippi and Louisiana by FRANCIS E. LLOYD and S. M. TRACY 1901; Plant Life of Alabama issued as volume six of Contributions from the United States National Herbarium 1901 by CHARLES MOHR; Report on a Botanical Survey of the Dismal Swamp Region by THOMAS H. KEARNEY 1901; the Flora of Tennessee by AUGUST GATTINGER; a Phytogeographical Sketch of the Altamaha Grit Region by ROLAND M. HARPER (1906). Finally a work published in New York in 1903 superceded the manuals of Southern botany previously published, when JOHN K. SMALL published his volume of 1370 pages entitled Flora of the Southeastern United States. This book already noticed in the introduction will long remain the authoritative work on flora of the South.

## V. Prairies, Arid Plains and Rocky Mountains.

At this point it is necessary to give some account of the early explorers and explorations that made known the south, middle west and the Rocky Mountain region. Probably the first extensive trip was undertaken by JOHN BARTRAM of Philadelphia. Neither dangers nor difficulties impeded or confined his researches after objects in natural history. The summits of the eastern mountains were ascended and explored by him. The lakes Ontario and George; the shores and sources of the rivers Hudson, Delaware, Schuylkill, Susquehanna, Alleghany were visited by him at an early period, when it was a perilous undertaking to travel in the territories, or even on the frontier. The results of this journey are recorded in Observations on the Inhabitants, Climate, Soil, Rivers, Productions made by Mr. JOHN BARTRAM in his travels from Pennsylvania to Onondaga, Oswego and Lake Ontario 1751. He traveled several thousand miles in Carolina and Florida. Arriving at Charlestown by sea he proceeded to St. Augustine, Florida and explored the St. Johns River of which he made an accurate draft and survey. His son WILLIAM BARTRAM traveled extensively in the southern states and an account of these journeys appeared in a book entitled Travels through North and South, East and West Florida 1791. PETER KALM, comes next as an explorer of North America and after spending sometime in the states, he proceeded by way of Albany and Lake Champlain to Canada making a somewhat prolonged stay at Quebec. His extensive collections went to LINNAEUS of whose herbarium they formed a part, yet distinguished from those of others by the initial K prefixed to the name of each specimen. Following Kalm came ANDRÉ MICHAUX, a student of BERNARD DE JUSSIEU, on a similar mission in 1785. With New York City, as headquarters, the first seven years of his work was directed to an exploration of the southern states, as far, as Florida and during that time he gathered a rich harvest of material. In 1792 he visited Canada proceeding by way of

Saratoga and Lake Champlain reached Montreal and Quebec which he left subsequently to visit the interior along the Saguenay and lakes St. John and Mistassini; thence towards Hudson Bay.

FREDERICK PURSH under the patronage of BENJAMIN SMITH BARTON set out early in 1805 for the mountains and western territory of the southern states beginning at Maryland and extending to the Carolinas returning late in the season through the lower country along the sea-coast to Philadelphia. The following season, he went north through Pennsylvania thence to Onondaga and Oswego down the Mohawk Valley to Saratoga and north to the upper part of Lake Champlain, the mountains of Vermont and New Hampshire returning by the seacoast [1].

F. ANDRÉ MICHAUX to collect information found it necessary to visit different parts of the United States. Beginning with Maine, he traveled over all the Atlantic states making five excursions into the interior parts of the country. The first along the rivers Kennebec and Sandy; the second from Boston to Lake Champlain crossing the states of New Hampshire and Vermont; the third from New York to Lakes Ontario and Erie; the fourth from Philadelphia to the borders of the rivers Monongahela, Alleghany and Ohio and the fifth from Charlestown to the sources of the Savannah and Oconee. In another journey described in Voyage a l'Ouest des Monts Alleghanys (Paris 1804). MICHAUX left Charlestown from New York presumably travelling by the sea coast through Raleigh, Richmond, Washington and Philadelphia to New York. From New York returning by Philadelphia, he left for the west by way of Lancaster, Pittsburgh, Wheeling, W. Va., Chillicothe, Ohio, through Kentucky to Nashville, passing through eastern Tennessee, mountainous North Carolina and across South Carolina on his way to Charlestown. This scientific journey of the younger Michaux in 1801 across the mountains into the Mississippi and Ohio valleys prepared the way for the subsequent explorations of the great territory extending westward to the Rocky Mountains.

Beyond the Mississippi, explored by FATHER MARQUETTE, all that was really well known was the territory in the immediate neighborhood of the little French villages at the mouth of the Missouri River. The headwaters of the Missouri were absolutely unknown. The Rocky mountains were not known to exist. The United States government undertook the task of exploration. The first of these expeditions was planned by JEFFERSON and authorized by the Congress. The explorers Captain MERIWETHER LEWIS and Lieutenant WILLIAM CLARK were chosen as leaders and were carefully instructed to report upon the geography, physical characteristics, botany and zoology of the region traversed. The young officers started on their trip from St. Louis in 1804 accompanied by twenty seven men. They made their way through the State of Missouri. From the Little Missouri at the head of the Missouri proper the explorers passed the plains and came to the mountains which they crossed

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1) Pursh F., Flora Americae Septentrionalis I 1814: ix.

so as to strike the headwaters of the Columbia, which they descended to the Pacific Ocean. In March 1806, they started eastward to retrace their steps. Early in July, the leaders separated for a time, Clark descending the Yellowstone and Lewis the Missouri, until they met at the junction of the two rivers and in September reached St. Louis, where they forwarded to JEFFERSON an account of what they had done. They had opened the great West to science and trade. — About this time DAVID THOMPSON, an astronomer and surveyor, in 1796 was sent by the North West Company to explore the source of the Mississippi. He visited the Mandan villages by way of Rainy Lake, lakes Manitoba and Winnipeg, Saskatchewan and Assiniboin rivers returning by way of the Red River of the North, Lake Superior and St. Louis River. On another expedition in 1806 he discovered the upper waters of the Columbia River, and was at Lake Athabasca in 1810. SIMON FRASER also figured in the exploration of the great Northwest.

While Lewis and Clark were descending the Columbia, another army officer was conducting explorations which were scarcely less important than theirs. In 1805 ZEBULON PIKE turned his face towards the headwaters of the Mississippi River. The winter was spent in what is now Minnesota. In his search for the source of the Mississippi, Pike penetrated a lake-dotted region and explored the Leech Lake drainage system. Returning to St. Louis, he started for the Southwest. He crossed the great plains to the Arkansas River and then up that river, where WILKINSON and three other men left the party and returned down to the river to the settled country. The others struck westward across the mountains reaching in November the bold peak which was afterward named in the leader's honor. They finally reached after much privation and hardship the Rio Grande River. PIKE was made prisoner by the Spaniards at Santa Fe and after release was sent home by a round about route through Chihuahua and Texas, and so ended the second great transcontinental expedition. Others followed in rapid succession. Those in which botany was given a prominence must now be mentioned.

THOMAS NUTTALL, an Englishman, long resident in Philadelphia, accompanied by BRADBURY left St. Louis in 1809, crossed the Kansas and Platte rivers and ascended the Missouri River, returning enriched with much material. Leaving Philadelphia again in 1818, NUTTALL reached the mouth of the Arkansas River and botanized extensively in the region returning with large collections which formed the basis for his book a Journal of Travels into the Arkansas Territory during the year 1819, Philadelphia 1821. In 1819 Major STEPHEN H. LONG was deputed by President MONROE to discover, if possible the South Pass, and on his return make an attempt to determine the sources of the Red River. Proceeding up the Missouri and its South Fork, they reached the mountains where the lofty mountain (Long's Peak) was discovered, the party returning homeward via, the Arkansas River. The results of the expedition led by Governor CASS appeared in Silliman's Journal in 1822 by JOHN TORREY. The plants collected by THOMAS SAY in LONG's second expedition

to the Northwestern Territory in the year 1823 were repeated upon by L. D. DE SCHWEINITZ in 1824. NUTTALL and JOHN K. TOWNSEND sent out jointly by the American Philosophical Society and the Academy of Natural Sciences of Philadelphia joined Captain WYETH's party at Independence, Missouri from which place they started April 28th, 1834. The account of the journey is given in TOWNSEND's Narrative of a Journey across the Rocky Mountains to the Columbia River. On September 3th, they began to descend the Columbia River reaching Fort Vancouver. Here the two naturalists remained for the rest of the Autumn exploring the surrounding country. Later they visited the Hawaiian islands. Two important memoirs, the fruits of the trip across the continent, were published in the Transaction of the American Philosophical Society in 1814 and 1842. — JOHN TORREY contributed the list of plants collected on a reconnoissance from Fort Leavenworth, Missouri, to San Diego, California, given in EMORY's Report of Reconnoissance, 1848 and also studied the plants collected during Captain MARCH's exploration of the Red River of Louisiana in 1852.

Passing over a lot of minor expeditions and surveys we come finally to the period of the great surveys beginning with the United States and Mexican Boundary Survey under W. H. EMORY and published in the report in 1858, appears the botany of the expedition by JOHN TORREY. In the Reports of Explorations and Surveys to ascertain the most practicable and economical Route for a Railroad from the Mississippi River to the Pacific Ocean (Washington 1855—61, 12 volumes) appear reports of the collections of plants made by the botanists of the several expeditions. The second volume treats of the 41st Parallel expedition under E. G. BECKWITH; the 38th and 39th Parallel under J. W. GUNNISON and the 32nd Parallel under J. POPE. The botany of these surveys was elaborated by JOHN TORREY and ASA GRAY. The fourth volume deals with the survey of the 36th Parallel under A. W. WHIPPLE, the Cactacae by GEORGE ENGELMANN and J. M. BIGELOW, the general botanic collections by J. TORREY and A. GRAY; the mosses and liverworts by W. S. SULLIVANT. The fifth volume contains the material of the 35th and 32nd Parallel California expedition under R. S. WILLIAMSON. The botanic portion of the report is by J. TORREY, E. DURAND and T. C. HILYARD. The sixth volume (1857) deals with the California and Oregon Survey under R. S. WILLIAMSON, the botany by J. S. NEWBERRY, J. TORREY, A. GRAY, W. S. SULLIVANT and E. TUCKERMAN. The seventh, the report of the 32nd Parallel and California under J. G. PARKE contains a botanic portion by JOHN TORREY. Volume twelve, the last one, deals with the surveys of the 47th and 49th Parallels under I. STEVENS, J. G. COOPER reports on the botany of the route and there is included a catalogue of plants collected east of the Rocky mountains and one of Washington Territory. Finally with reference to the great expedition of the middle West must be mentioned S. WATSON and D. C. EATON's Botany of the Fortieth Parallel 1871, ROTHROCK's botany of the United States Geographical Surveys west of the one hundredth meridian in charge of G. M. WHEELER, Washington

1878, and the report by J. S. NEWBERRY, entitled Notes on the Geology and Botany of the Country bordering the Northern Pacific Railroad 1884.

With the adoption of a forest policy and the creation of forest reserves, a renewed stimulus has been given to botanic survey of the far west in the interests of forest botany. Several voluminous reports each with numerous plates and maps have been issued. The nineteenth (1897—98), twentieth (1899), twenty first (1899—1900) contain a botanic description of the various forest reserves set aside by presidential proclamation.

The Rocky Mountain Region of the United States is fairly well known botanically. The botanists of the various great transcontinental surveys have visited it and plants have been collected in nearly all of the important ranges and mountain valleys. With the spread of civilization westward and the erection of several universities in the Rocky Mountain states, more attention has been paid to the mountain flora with the appearance of a class of the population interested in the study and preservation of the wild plants.

In addition to some of the reports and journeys mentioned above that touch upon Rocky Mountain botany should be mentioned the journey of EDWIN P. JAMES in the summer of 1820 to and from the Rocky mountains and his collection of plants determined by JOHN TORREY. The plants, collected on the expedition led by NATHANIEL B. WYETH, were reported by THOMAS NUTTALL in a catalogue published in 1834 in the Journal of the Philadelphia Academy of Natural Sciences. — The expedition of Lieutenant JOHN C. FREMONT was most important and fruitful of results. He began his arduous enterprise, that of exploring the Rocky mountains and opening an overland route to the Pacific Ocean under authority of the government in May 1842. He examined the South Pass of the Rocky mountains, and ascended in August the highest peak of the Wind River mountains (13,570 feet) now called Fremont's Peak. In the autumn of 1842, he returned to Washington and published report of his discoveries with a catalogue of plants by JOHN TORREY (p. 77—94) in 1843. In the summer of 1843 he conducted another expedition up the valley of the Platte and through the South Pass, explored Great Salt Lake, arriving in November at Fort Vancouver, near the mouth of the Columbia River and the next spring reached the Sacramento River in March 1844, returning through the Great Basin and the South Pass. In the spring of 1845, he conducted a third expedition to explore the Sierra Nevada and California and organized and conducted a fourth in 1848.

The next exploration of interest was by F. V. HAYDEN whose report to the Government is entitled, Catalogues of Plants collected during the Expedition of F. V. HAYDEN to the Headwaters of the Yellowstone River, in the Summer of 1871 with a Small Number by Dr. GEORGE SMITH in August 1871, on Gray's Peak and near Georgetown, Colorado by T. C. PORTER (The Mosses by L. LESQUEREUX and Lichens by E. TUCKERMAN) Washington 1871. The catalogue of plants collected by HAYDEN in Wyoming and Colorado during 1868, 1869 and 1870 is also by T. C. PORTER, published in 1872.

J. M. COULTER issued in 1873, under government auspices, a Catalogue of Plants collected in 1872 in Portions of Montana, Idaho, Wyoming and Utah.

The state floras have not been neglected. One of the first for the mountain region is entitled Enumeration of the Species of Plants collected by Dr. C. C. PARRY and Messrs. E. HALL and J. P. HARBOUR during the Summer and Autumn of 1862 on and near the Rocky mountains in Colorado Terr. by ASA GRAY published in the Proceedings of the Academy of Natural Sciences of Philadelphia in 1863.

The Synopsis of the Flora of Colorado by T. C. PORTER and J. M. COULTER, printed as a government publication in 1874, is often referred to in the earlier works on the botany of the western United States. It, and the Flora of Southwestern Colorado by T. S. BRANDEGEE (1876) are the most important of the early papers dealing with the botany of the State. ASA GRAY and J. D. HOOKER later in 1881 printed a paper in which they compared the vegetation of the Rocky Mountain Region with other parts of the world mentioning the more salient features of the mountain flora. — Two papers dealing with the phytogeography of the Rocky mountains are in line with the paper of Gray and Hooker. Reference is made to an article by T. D. A. COCKERELL in Science (May 6th, 1898) on the Diverse Floras of the Rocky Mountain Region and to another by P. A. RYDBERG entitled Composition of the Rocky mountain Flora also published in Science (1900).

The Yellowstone Region is now well represented by floras and papers on its botanic aspects. One of the first published by the government in 1882 is a List of Plants collected on Lieut. General P. H. SHERIDAN's Expedition through the Big Horn Mountains, Yellowstone National Park, etc. in 1881 by Surgeon W. H. FORWOOD. TWEEDY's Flora of the Yellowstone National Park was printed in pamphlet form in 1886. The vegetation of the hot springs has also received a considerable share of attention and articles by WEED, BAY, HARSHBERGER, DAVIS, SETCHELL and TILDEN have appeared on the subject. The most voluminous work, however, is RYDBERG's Catalogue of the Flora of Montana and the Yellowstone Park issued as the first volume of Memoirs of the New York Botanical Garden in 1900. In this work, the author gives an account of the herbaria consulted, the botanists engaged in field work and the localities visited. Besides these papers on the Flora of Idaho, Coeur d'Alene mountains, Big Horn mountains, Black Hills of Dakota, Bitterroot mountains, Teton mountains have been published as Contributions from the United States National Herbarium and as reports in the United States Geological Survey, Annual Reports 19th, 20th and 21st. AVEN NELSON has contributed notes and has written a Flora of Wyoming. The only general work for the region is the Manual of the Botany of the Rocky Mountain Region from New Mexico to the British Boundary by JOHN M. COULTER. The first edition, which only claims to be a compilation, an orderly arrangement of scattered material, was published in 1885. This work is in need of revision and P. A. RYDBERG is at work upon a manual which will fill the long felt want of an

authoritive handbook on the flora of the Rocky Mountain Region, his preliminary work appearing as Flora of Colorado (1906).

The Great Basin Region has been mentioned incidentally in the accounts of the exploration of the west and the Rocky Mountain Region. One of the first reports on the Great Basin proper was printed at Philadelphia in 1852. It is an account by HOWARD STANSBURY of the exploration and surveys of the valley of the Great Salt Lake, which includes a catalogue and description of plants by JOHN TORREY. Torrey also elaborated the catalogue of plants collected by Captain L. SITGREAVES on an expedition down the Zuni and Colorado rivers about 1854. DURAND later in 1860 contributes to the Transactions of the American Philosophical Society descriptions of the species constituting the flora of the Great Salt Lake Basin and Drs. GRAY, TORREY, THURBER and ENGELMANN, a botanic report on the expedition of Lieut. J. C. FREMONT in 1857—58 to the Colorado River of the West. A Catalogue of Plants collected in 1872 in Utah, Wyoming, etc. by J. M. COULTER is the title of a paper published by the U. S. Geological Survey of Montana, Idaho, Wyoming and Utah in 1873.

The work, however, which may be said to represent the flora of the region in the most comprehensive manner is the Botany of the Fortieth Parallel, Washington 1871, by SERENO WATSON and D. C. EATON. Several other works must be mentioned dealing with the flora of the arid region in completing this general survey, viz., Report of Explorations across the Great Basin of the Territory of Utah by J. H. SIMPSON 1876; Catalogue of Plants collected in Nevada, Utah, Colorado, New Mexico and Arizona, as volume V of the reports on U. S. Geological Survey west of the One Hundredth Meridian, (Lieut. WHEELER in charge) by J. T. ROTHROCK, Washington 1878 and COVILLE's Botany of the Death Valley Expedition 1893, issued as volume IV of Contributions from the United States National Herbarium.

## VI. Pacific Coast.

The finely equipped scientific expedition of LA PEROUSE left France in 1785. On September 14th, 1786 the ship anchored in Monterey Bay where the botanists of the expedition MARTINIÈRE and COLLIGNON took advantage of the stop to collect California plants [1]). The first one described by LAMARCK was *Abronia umbellata* secured by Collignon. The next botanists to visit California were THADDEUS HAENKE and LUIS NEE who accompanied the Spanish expedition under MALASPINA, which touched the coast at San Diego and Monterey in 1791. Between 1789 und 1817 HAENKE botanized along the western side of the American continent from Patagonia to Bering Strait. His collections are in part at Prague and were described by PRESL in Reliquiae and part in the herbarium of the Royal Garden at Madrid. Through a confusion of labels, some of his plants described as Chilian were probably col-

1) See WILLIS L. JEPSON, Early Scientific Expeditions to California Erythea I: 185.

lected in California; while some credited to California were, with little doubt, really from the East Indies or elsewhere. — ARCHIBALD MENZIES, who had earlier visited the northwest coast in 1786, in November and December 1792, visited San Francisco Bay, Santa Clara and Monterey, touching the coast again in 1793 and 1794. A set of his collections is in the British Museum, another at Kew, and a portion of his earlier collections, particularly the cryptogams, are in the herbarium of the Botanical Society of Edinburgh. JOSEF MARIANO MOÇINO was on the coast in the year 1792. He afterward botanized in Mexico, especially in the northern parts, along with MARTIN SESSE. The large collection of drawings which Moçino brought to Europe after the death of Sesse contains delineations of Californian species, but most of them are Mexican. This collection of twelve hundred drawings (cited as Ic. Fl. Mex. ined., and on which a number of genera and species were founded) was left by Moçino in the hands of DECANDOLLE and afterward suddenly reclaimed. It is said that the herbarium made by MOÇINO and SESSE went to Madrid; but a portion was certainly acquired by LAMBERT, and in the disposition of his collections is thought to have been acquired by the British Museum. GEORGE HEINRICH VON LANGSDORF visited California in the Russian ship Juno, and it is supposed again in 1824. His botanical collection was meagre. ADALBERT VON CHAMISSO, as botanist, and JOHANN FREDRICH ESCHSCHOLTZ, as surgeon and naturalist, were in the expedition fitted out by Count ROMANZOFF, under Captain KOTZEBUE visiting California in 1816. Descriptions of the plants were published by Chamisso and Schlechtendal in Linnaea, in ten volumes from 1825 to 1834, and by Eschscholtz in a paper entitled Descriptio Plantarum Novae Californiae in the Memoirs of the Academy of St. Petersburg in 1823. ESCHSCHOLTZ again accompanied Kotzebue on his second voyage to California, arriving in September 1824.

The English expedition under Captain BEECHEY (1825 to 1828) reached California late in 1827. ALEXANDER COLLIE, surgeon to the expedition and G. TRADESCANT LAY made a collection of about one hundred and seventy-five species. The specimens in a bad shape were studied by HOOKER and ARNOTT and the results of their labors appeared in their Botany of Captain Beechey's Voyage. DAVID DOUGLASS, a Scotch botanist, reached the northwest coast early in 1825. He botanized extensively in Washington and Oregon. On a second trip from England, he again reached the coast in 1830 and in December of that year came to California, where he botanized from Sonoma County to Monterey. In 1832 he went by way of the Sandwich Islands to the Columbia, back again to the Hawaiian group, where he lost his life a few months later. An indefatigable collector, a close observer and an enthusiastic traveller he added more to the knowledge of the botany than all the botanists who had gone before him. His Californian collections were chiefly described in the supplement to the Botany of Captain Beechey's Voyage, and those from Oregon and Washington in HOOKER's Flora Boreali-Americana. HOOKER's, LINDLEY's and BENTHAM's herbaria contain sets of his Californian plants and

many specimens are found elsewhere. Dr. THOMAS COULTER, who botanized extensively in California, was the first botanist to reach the Colorado Desert and Gila regions. He collected more than a thousand species in Mexico and California.

HARVEY of Trinity College, Dublin, distributed duplicate sets of COULTER'S plants to the Hookerian herbarium and to those of GRAY and TORREY. THOMAS NUTTALL, as previously stated, crossed the continent in an expedition under Captain WYETH in 1834 to the Columbia River, thence to the Sandwich islands, returning to California, where he collected during part of the year 1835. His collections were very rich and many of them are in the Gray Herbarium at Harvard University and many in the Academy of Natural Sciences of Philadelphia. The names of RICHARD BRINSLEY HINDS, WOSNESSENSKY, WILLIAM D. BRACKENRIDGE, CHARLES PICKERING, DUFLOT DE MOFRAS, WILLIAM GAMBEL, JOHN C. FREMONT, NORMAN BESTOR and THEODOR HARTWEG, whose collections were enumerated by BENTHAM in Plantae Hartwegianae, are prominent in the botanic annals of Spanish occupancy. The plants collected by WILLIAM GAMBEL were described by THOMAS NUTTALL in the Journal of the Academy of Natural Sciences for 1848. Plantae Fremontianae, or Descriptions of Plants collected by Col. J. C. FREMONT in California by JOHN TORREY appeared in 1850. This brings us to the second period beginning with the great immigration of 1849.

GEORGE THURBER of the Mexican Boundary Survey reached California late in 1851. Descriptions of some of his new species were published by ASA GRAY in Plantae Thurberianae. J. M. BIGELOW, ARTHUR SCHOTT and CHARLES WRIGHT collected plants on the Mexican Boundary Survey. ALBERT KELLOGG came to San Francisco in 1849 and during more than thirty years he collected along the coast from Alaska to San Diego. Some of his specimens are in the herbarium of the California Academy of Sciences and others are scattered in various places. In passing the following botanists should be mentioned as identified with the botany of the Pacific Coast: J. D. B. STILLMAN, HENRY BEHR, GEORGE GIBBS, WILLIAM LOBB, GEORGE BLACK, T. L. ANDREWS, G. E. HULSE, A. WISLIZENUS, N. J. ANDERSSON, A. F. BEARDSLEY, JOHN JEFFREY, H. G. BLOOMER, and WILLIAM A. WALLACE.

Many plants were collected within the State of California from 1853 to 1855 by botanists connected with the Pacific Railroad explorations. The largest of these collections was made by J. M. BIGELOW, under Lieut. WHIPPLE, the entire collection from Arkansas to California amounting to about twelve hundred species, of which over eleven hundred (excluding Cactaceae and Mosses) were enumerated in the fourth volume of the Pacific Railroad reports. These plants, as well as those of the other government expeditions, were determined chiefly by TORREY and GRAY, and they are found in the herbaria at Cambridge, New York and Washington and in foreign countries at Kew and St. Petersburg. A. L. HEERMANN accompanied WILLIAMSON'S Survey in 1853 and collected one hundred species noticed by DURAND and HILGARD in volume

five of the Pacific Railroad reports. WILLIAM P. BLAKE made collections in southern California described by TORREY in the same volume as the above. J. S. Newberry collected under Lieutenants WILLIAMSON and ABBOTT, mostly in Oregon and northern California. Over five hundred species were reported by him from this region. He also went with Lieutenant JONES in 1857—58 along the Colorado River and through northern Arizona. THOMAS ANTISELL was connected with the party of Lieutenant PARK and collected in 1854 between Salt Lake and the Sacramento River. Passing with a mere mention the labors of J. F. HAMMOND, CHARLES WRIGHT, AMOS B. EATON, THOMAS BRIDGES and L. J. XANTUS DE VESEY we come to the work done by the California State Geological Survey organized by J. D. WHITNEY in 1860. In connection with this survey were WILLIAM H. BREWER, who collected from 1860 to 1864, FRANCISCO GUIRADO in 1860 and 1861, EDWARD PALMER in 1861, HENRY N. BOLANDER 1863 and for twelve years subsequent, GEORGE H. HORN, WILLIAM HILLEBRAND of Honolulu and V. RATTAN. The botanic results appeared in two volumes issued by the *Geological Survey of California*. The first volume by W. H. BREWER, SERENO WATSON and ASA GRAY appeared in 1876, the second volume by SERENO WATSON in 1880. Besides the above named explorers, the west coast of the United States was visited by HORACE MANN, JOHN TORREY, ASA GRAY, J. D. HOOKER, ALPHONSO WOOD and GEORGE L. GOODALE. The names also of C. L. PARRY, EDWARD PALMER, C. G. PRINGLE, J. T. ROTHROCK and W. K. SUKSDORF are prominently identified with the botany of the Pacific Coast. In 1885 C. R. ORCUTT published a Flora of Southern and Lower California. J. G. LEMMON, MRS. LEMMON, ABBOTT KINNEY and other botanists were connected with the publication of the First Biennial Report of the California State Board of Forestry for the years 1885—86 (Sacramento 1886), the Second Biennial Report for the years 1887—88 (Sacramento 1888), and the Third Biennial Report for the years 1889—90 (Sacramento 1890) in which is set forth a detailed account of the condition of the forests and a botanic description of the principal forest trees. J. G. LEMMON has also printed a work entitled Handbook of West-American Cone-Bearers (third edition 1895), also in pamphlet form, Oaks of Pacific Slope (1902).

Numerous articles on the flora of the mainland and the coast islands of California have been published in Erythea, Zoë, Pittonia, Garden and Forest, Bulletin of the Torrey Botanical Club and Botanical Gazette. The following botanists have been prominently identified with the botany of California and the articles in the above mentioned journals have been largely contributed by them. E. L. GREENE, W. L. JEPSON, ALICE EASTWOOD, W. R. DUDLEY, S. B. PARISH, CARL PURDY, W. A. CANNON, F. V. COVILLE, T. S. BRANDEGEE and (Mrs.) KATHERINE BRANDEGEE. Chronologically arranged, the following books and papers deal with Californian phytogeography. Illustrations of West American Oaks, by EDWARD L. GREENE appeared in 1889—90. Flora Franciscana by the same botanist, as its title page suggests, is an attempt to

classify and describe the vascular plants of middle California. Parts I, II, III appeared in 1891—92; Part IV was issued in 1897. Manual of the Botany of the Region of San Francisco Bay by EDWARD L. GREENE was printed in 1894. Under the auspices of the Division (now Bureau) of Forestry of the United States appeared in 1900, as bulletin 28, A short Account of the Big Trees of California. WILLIS LINN JEPSON, assistant professor of botany in the University of California, published a Flora of Western Middle California in 1901. WILLIAM R. DUDLEY contributed to the Sierra Club Bulletin in June 1901 a paper on the Zonal Distribution of Trees and Shrubs in the Southern Sierra and ALICE EASTWOOD in the same journal in June 1902, a Flora of the North Fork of Kings River. The first volume of University of California publications (Botany) includes a paper of one hundred and forty pages entitled a Botanical Survey of San Jacinto Mountain by HARVEY M. HALL (1902). JOSEPH BURTT DAVY, late of the University of California, now in South Africa, describes the stock ranges of northwestern California in one of the bulletins (No. 12) of the Bureau of Plant Industry U. S. Department of Agriculture. The Botanical Gazette for September and October 1903 contains a sketch of the Flora of Southern California by S. B. PARISH. The list is not completed with this enumeration; but enough has been given to show the character of the work done upon the California flora.

It only remains to describe the flora of the northwest Pacific Coast. The early explorations to this region have been previously mentioned. The more recent publications dealing with the botany of the northwestern United States are few in number. THOMAS HOWELL began the publication of a Flora Northwest America in 1897 with the first fascicle, Ranunculaceae to Rhamnaceae. The second appeared in 1898; the third in 1900; the fourth and fifth in 1901; the sixth in 1902 and the last fascicle (no. 7) of the first volume in 1902. The fifteenth bulletin of the United States Division of Forestry, issued in 1898, deals with the Forest Growth and Sheep Grazing in the Cascade Mountains of Oregon by F. V. COVILLE. W. L. JEPSON published in 1899 in Erythea a paper on the Vegetation of the Summit of Mt. St. Helena and F. V. COVILLE contributed to Mazama in 1900, one on the August Vegetation of Mount Mazama, Oregon. — The forest reserves of Washington, are described by H. P. AYRES and M. W. GORMAN in the 19th Report U. S. Geological Survey 1899. The Mount Rainier, Olympic Forest and Cascade Range Forest reserves receive attention in the 21st Report 1900. The Flora of the Palouse Region published by the Washington Agricultural College and School of Science in 1901 is by CHAS. V. PIPER and R. KENT BEATTIE. It contains descriptions of all the spermatophytes and pteridophytes growing wild in the area within thirty-five kilometers of Pullmann, Washington. One of the latest publications to deal with the flora of this region is entitled Forage Conditions and Problems in Eastern Washington, Eastern Oregon, Northeastern California and Northwestern Nevada by DAVID GRIFFITHS, issued as bulletin 38 of the United States Bureau of Plant Industry in 1903. Lastly must be mentioned a publi-

cation on the Algae of the Northwestern America by WILLIAM A. SETCHELL and NATHANIEL L. GARDNER in University of California Publications Botany (Volume I: pp 165—418. 1903) and CHAS. V. PIPER published in 1906 a Flora of the State of Washington as Contributions from the U. S. National Herbarium, vol. XI.

The botanic centers on the Pacific Coast are three in number located at the University of California at Berkeley, at the San Francisco Academy of Sciences and at the Leland Stanford Junior University at Palo Alto. The botanists connected with the University of California are E. W. HILGARD, WILLIAM A. SETCHELL, WILLIS L. JEPSON with the San Francisco Academy as Curator of the herbarium, ALICE EASTWOOD with the Stanford University, DOUGLASS H. CAMPBELL, WILLIAM R. DUDLEY and GEORGE J. PEIRCE. A botanic garden is maintained at Berkeley and also experimental grounds in connection with the agricultural experiment station.

## VII. Great Southwest.

In addition to the reports and papers issued by the government, which contain the results of the botanic survey of the great Southwest should be mentioned one by GEORGE ENGELMANN, on the Character of the Vegetation of Northwestern Texas printed in the Proceedings of the American Association for the Advancement of Science for 1851, and by the same botanist, Geography of the Cactus Region of the United States, published in the third volume of the Proceedings of the American Academy of Arts and Sciences. O. LOEW published in the sixth volume of the report upon the geographic and geologic explorations and surveys west of the one hundredth meridian in charge of Lieutenant GEORGE M. WHEELER investigations upon mineralogic and agricultural conditions observed in portions of Colorado, New Mexico and Oregon in 1873 with an account of the geographic distribution of the plants of the region visited, and later in 1876 a Report on the Geographical Distribution of Vegetation in the Mohave Desert. GEORGE VASEY in the thirteenth volume of the Botanical Gazette gives an account of the characteristic vegetation of the North American desert. The most important work on the botany of the arid region of the southwestern United States up to the publication of J. M. COULTER's Manual of the Phanerogams and Pteridophytes of Western Texas, issued as volume II of Contributions from the United States National Herbarium 1891—94, is without question the Catalogue of Plants collected in the years 1871, 1872 and 1873 with Descriptions of New Species known usually as ROTHROCK's Botany of the Wheeler Survey, published by the government in 1874. As Contributions from United States National Herbarium were published by J. N. ROSE lists of plants collected by EDWARD PALMER in New Mexico and Arizona in 1890, and J. W. TOUMEY in the Botanical Gazette for 1892 contributes a List of the Flora of Central Arizona. The question of the bacterial content of the air of desert regions has received attention, JOHN WEINZIRL publishing in 1900 in the Proceedings of the

American Association for the Advancement of Science an account of the bacterial flora of the semi-desert region of New Mexico with special reference to the bacteria of the air. The ecologic aspects and phytogeography of the region under consideration have been provided for by WILLIAM L. BRAY in the Ecological Relations of the Vegetation of Western Texas, published in the Botanical Gazette for 1901 and the Tissues of Some of the Plants of the Sotol Region, printed in the Bulletin of the Torrey Botanical Club of November 1903.

Recently under grant of funds from the Carnegie Institution of Washington the continuance of botanic investigation is provided for in the establishment of a desert botanic laboratory for research at Tucson, Arizona. Much may be expected from this station in the way of elucidating the geographic distribution of desert plants from a physiologic-ecologic standpoint. Several illustrated reports have appeared as publications of the Carnegie Institution entitled: Desert Botanical Laboratory of the Carnegie Institution, dealing with the desert floras of North America, the first in November 1903 by FREDERICK V. COVILLE and DANIEL T. MACDOUGAL.

## VIII. Mexico.

The most important books on the botany of Mexico will be listed in the bibliography which follows. It is advisable, however, at this place to give a brief historic resume of the botanic explorations in Mexico. Relaciones de Indias published by the authority of PHILLIP II, King of Spain, in the year 1568 and 1569 contains much of interest to the phytogeographer, but this work is rivalled by that of FRANCISCO HERNANDEZ, a Spanish physician and naturalist, who was commissioned by Phillip II to visit North America and to describe the plants, animals and minerals found therein. The results of his labors and travels, expecially in Mexico, was a work in a Latin edition entitled Rerum Medicarum Novae Hispaniae Thesaurus seu Plantarum, Animalium, Mineralium Mexicanorum Historia 1649. WILLIAM HOUSTON, a student of BOERHAAVE at Leyden visited the West Indies and later Mexico about 1729. His collections found their way to PHILIP MILLER and the plants are frequently referred to in the Gardener's Dictionary and also in JOHN MARTYN's Historia Plantarum Rariorum 1728—32. On the death of Houston, JOSEPH BANKS collected his notes and published them in 1781 under title of Reliquiae Houstonianae. The specimens collected by him are in the British Museum. LUIS NÉE accompanied the expedition of Malaspina and with THADDEUS HAENKE visited Mexico. The collection of Née repose in the herbarium of the Botanic Garden at Madrid. Haenke's collections are scattered in the herbaria of Prague, Vienna and Kew. The results of his exploration appeared in five fascicles entitled Iter mexicanum and Plantae mexicanae. PRESL who described his botanic collections published two volumes Reliquiae Haenkeanae in 1830—36.

The botanic expedition inaugurated by CHARLES III of Spain, was projected to explore the countries collectively called New Spain. Several scientists were engaged in the survey and among them may be named MARTIN SESSE, JUAN

DIEGO DEL CASTILLO, JUAN CERDA, D. VINCENTE CERVANTES and D. MARIANO MOÇINO. MOÇINO explored the coasts of Tabasco and Guatemala and later the region inhabited by the Tarahumaras. During the years 1795 to 1804, the work of the scientific commission was most actively prosecuted. The fruits of the conjoint labors of the members of the commission were a good herbarium and a work in manuscript entitled Flora Mexicana. With a rich herbarium, an excellent collection of 1400 colored drawings the work of ECHEVARRIA and CERDA and with their previous manuscript SESSE and MOÇINO departed for Spain with the idea of publishing the results of the expedition. Delays, fatal to the enterprise, discouraged the hopes of Moçino and Sesse, and it was not until long after their death in 1888 that the flora appeared as a publication of the Mexican Society of Natural History, as "Flora Mexicana Autoribus Martinus Sesse et Josephus Marianus Moçino".

ALEXANDER VON HUMBOLDT and AIME BONPLAND passed nearly a year in the exploration of Mexico, debarking at Acapulco on March 13, 1803, visited the United States and returned to Europe in July 1804 with rich collections of plants, animals and minerals. BONPLAND was the virtual botanist of the expedition and he collected 6,000 species of plants which are preserved in the Museum of Natural History at Paris. He published *Nova Genera et Species Plantarum* (7 volumes, folio with 700 plates, 1815) and Equinoctial Plants collected in Mexico, Cuba, etc. (2 vols. folio 140 plates).

Passing over the names of TATE, LEXARZA, SARTORIUS and KARWINSKI, we come to that of JOHN LOUIS BERLANDIER, who collected in Tamaulipas, San Luis Potosi, Nuevo Leon and Coahuila during the years 1827—30. Part of his collections is in the Kew Herbarium. SCHIEDE and DEPPE visited Mexico about 1828 and collected near Jalapa, Orizaba and Cuernavaca. The results of their labors and those of HEGEWISCH and MUEHLENPFORDT were contributed to Linnaea by SCHLECHTENDAHL and CHAMISSO. H. M. S. "Blossom" touched at Mexico in 1828 and MR. LAY explored Tepic and Jalisco. HOOKER's herbarium, DELESSERT's herbarium and that of Kew contain the specimens collected by this expedition. THOMAS COULTER collected in Mexico for many years. During 1832 and 1833, he explored Alta California and Sonora. His collections were deposited in the herbarium of Trinity College, Dublin, where they were studied by W. H. HARVEY. G. ANDRIEUX, who visited Mexico for plants, sent his collections to DELESSERT, HOOKER and DE CANDOLLE. HENRY GALEOTTI, AUGUST B. GHIESBREGHT, JOHN J. LINDEN and NICHOLAS FUNCK extensively explored Mexico during the years 1836—40 and made large collections of plants. They ascended the peak of Orizaba, and Galeotti alone Popocatepetl, reaching the limit of vegetation at an elevation of 10,500 feet. Their plants were distributed to several of the large European herbaria.

THEODORE HARTWEG was sent by the Horticultural Society of London to Mexico in 1836 with the object of collecting living plants and seeds. He explored the mountains at Guanajuato, Leon, Lagos, Guadalajara, Aguas Calientes, Morelia and Oaxaca and left Mexico in 1839 for Guatemala. His

collections of plants both living and dry were described by GEORGE BENTHAM in his Plantae Hartwegianae, 1839—42. This botanist also described the plants gathered together by the botanists of the Voyage of H. M. S. Sulphur. JOHN PARKINSON, FREDERICK E. LEIBOLD, DUFLOT DE MOFRAS, JOHN POTTS, CARLOS HELLER, AUDIN ASCHENBORN and A. WISLIZENUS collected in Mexico. FREDERICK M. LIEBMANN, a Dane, was sent to Mexico to make botanic and scientific collections. He disembarked at Vera Cruz in February 1844. He explored various parts of Mexico and consigned to the herbarium in Copenhagen 40,000 plants and a notable zoologic collection. Subsequently he published a book in Danish called "Mexicos Bregner, en systematisk, critisk, plante-geographisk Undersögelse 1849", and later with A. S. OERSTED appeared Les Chênes de l'Amerique tropicale (1868). BERTHOLD SEEMANN, as botanist of the expedition sent out in H. M. S. "Herald", collected plants in Panama and Mexico. These plants are at Kew. BOTTERI, MUELLER, HAHN, SCHAFFNER, ERVENDBERG, BOUGEAU, THIEBAUT, BILIMEK and VILLADA are botanists identified with the progress of Mexican botany.

The botanists from the United States, who have visited and explored Mexico for botanic purposes, are the following: C. C. PARRY, EDWARD PALMER, CYRUS G. PRINGLE, J. N. ROSE, E. W. NELSON, CHAS. F. MILLSPAUGH, WILLIAM TRELEASE, JOHN W. HARSHBERGER, V. HAVARD, E. D. HOLWAY, ANGELO HEILPRIN, WITMER STONE, C. J. CHAMBERLAIN, D. J. MACDOUGAL and JOSEPH PAINTER. C. C. PARRY crossed the Mexican boundary for the purpose of collecting plants. His botanic explorations were confined mainly, however, to the southwestern United States. We owe our knowledge of Mexican plants very largely to the efforts of Dr. EDWARD PALMER and CYRUS G. PRINGLE, who have spent many years in Mexico. Palmer's collections have gone to the United States National Herbarium, and sets have gone to various of the leading herbaria. PRINGLE has done more than all the other botanists combined to explore and collect the plants of the Mexican Republic. For at least fifteen years, he has visited Mexico and has botanized in practically every state from the boundary south to Oaxaca. This work has been done with discriminating care, so that a majority of his plants have been described as new, or have enriched our botanic knowledge by the light they have thrown on the type specimens collected by the earlier botanists, or the localities where these types have been found. Pringle's plants have been described and named by the botanists at the Gray Herbarium of Harvard University. Sets of the several Mexican collections beginning with Asa Gray and Sereno Watson and continuing with B. L. Robinson and J. M. Greenman are to be found in all the large herbaria of the world. Pringle's private collections have lately been deposited in the herbarium of the University of Vermont. The published papers of this botanist on the Mexican flora have appeared in Garden and Forest.

E. W. NELSON has explored Mexico under the auspices of the Biological Survey of the United States Department of Agriculture. His work has been mainly along zoologic lines, but he has also made considerable collections of

dried plants for the U. S. National Herbarium. CHARLES F. MILLSPAUGH visited Yucatan making large collections, a report of which has appeared as Plantae Yucatanae, publications of the Field Columbian Museum. — J. N. ROSE has published extensively on Mexican plants. He has made at least three trips to the South and has returned enriched by botanic material. The results of these trips have appeared in the Contributions from the United States National Herbarium and elsewhere. — WILLIAM TRELEASE has been in Mexico twice in the interests of the herbarium of the Missouri Botanical Garden and in the furtherance of his studies on the genus *Yucca*. A report of one hundred and thirty-three pages and ninty-nine plates on the Yucceae was published in the Report of the Missouri Botanical Garden for 1902. — J. HARSHBERGER accompanied C. G. PRINGLE for a month in the exploration of the Valley of Mexico and the ranges of mountains thereabouts during August and September 1896, his collections being distributed to herbaria in Philadelphia, Cambridge, Washington, while a paper on the flora of the Valley of Mexico appeared in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1898. — ANGELO HEILPRIN and WITMER STONE collected in Mexico around and on the high volcanoes of Orizaba and Popocatepetl. Heilprin gave the results of the trip in a brochure entitled the Temperate and Alpine Floras of the Giant Volcanoes of Mexico, printed in the Proceedings of the American Philosophical Society in 1892. Their plants are in the Herbarium of the Academy of Natural Sciences of Philadelphia.

The coterie of Mexican botanists, who have been most active in extending the botanic knowledge about their country, are FERNANDO ALTIMIRANO, JOSE N. ROVIROSA, J. ELEUTERIO GONZALEZ, IGNACIO OCHOA VILLAGOMEZ, NICOLAS LEON, JOSÉ SEGURA, MARIANO BARCENA, ALFONSO HERRERA, JOSÉ RAMIREZ, MANUEL URBINA. Their papers have appeared in a number of journals prominently La Naturaleza and Anales Instituto Medico Nacional. A good herbarium is maintained in the building of the Medical Institute in the City of Mexico.

In concluding this short account of the history of Mexican botany mention of must be made of W. BOTTING HEMSLEY of Kew, who has published in four volumes the botany of the Biologia Centrali-Americana of Godman and Salvin; of ERNST STAHL of Jena and G. KARSTEN, who in 1894 explored parts of Mexico, returning to Germany by way of the United States.

## IX. Central America.

A number of the botanists mentioned above in connection with the history of Mexican botany explored Central America. However, it is well to briefly refer to those naturalists who explored Central America and to whom we are indebted for our botanic knowledge of that region. The voyage of H. M. S. "Sulphur" under Captain Sir EDWARD BELCHER touched at Panama, the Island of Tobago, the Gulf of Nicoya, Costa Rica and Nicaragua. The collections of dried plants were afterwards studied by GEORGE BENTHAM. In 1839

EMANUEL FRIEDRICHSTHAL performed journeys through a great part of Nicaragua and Costa Rica. — To ANDERS SANDOE OERSTED, we owe much of our knowledge of the botany of Costa Rica. This botanist spent three years in the country (1846—48) exploring that country and Nicaragua, chiefly the great volcanic chain which includes the peaks of Irazu, Barba and El Viejo. — JULIUS VON WARSCEWICZ, who made collecting humming birds and orchids a specialty, also made collections of plants. In 1846, he first went to Guatemala, thence to Salvador, Nicaragua, Costa Rica, Veraguas and Panama. — BERTHOLD SEEMANN during the voyage of H. M. S. Herald (1845—51) explored Panama, Veraguas and Mexico. The first set of Panamaian and Mexican plants are at Kew, where they were worked upon by SEEMANN, JOSEPH HOOKER and A. A. BLACK, who conjointly elaborated The Botany of the Voyage of the Herald. — RALPH TATE collected at Chontales, Nicaragua and HUGH CUMING in Tobago Island, Pearl islands, Montijo Bay and along Chiriqui River in 1829, while PLACIDE DUCHASSAING de Fontbressin visited Panama collecting many novelties that were described by WALPERS and GRISEBACH. — THOMAS BRIGGS visited Veraguas and Costa Rica in 1856 for plants, E. P. JOHNSON, Yucatan and Tabasco and HERMANN WENDLAND in 1856 spent eight months in Costa Rica and Nicaragua. — AUGUST FENDLER collected plants in Panama, Nicaragua and Trinidad, where he died in 1883. A good set of his Panama collections is in the Kew Herbarium. — CARL HOFFMANN and ALEXANDER VON FRANTZIUS left Europe for Costa Rica in 1853. Subsequently Hoffmann in Bonplandia 1858 published several papers on the vegetation of Costa Rica especially that of the Volcan de Cartago and Volcan de Barba. SUTTON HAYES botanized in Panama from 1860—63. His plants are at Kew. MORITZ WAGNER traveled and collected in Panama and Costa Rica. —

The editors of Biologia Centrali-Americana OSBERT SALVIN and FREDERICK DU CANE GODMAN visited Guatemala on several occasions between 1857 and 1874. They made a collection of some 220 species of ferns in the region of Volcan de Fuego and Volcan de Agua. At Kew are two separate sets of flowering plants, 250 species, dated 1861, and 350 species, dated 1873—74, representing the labors of these two men. — E. PAUL LEVY collected in the neighborhood of Segovia, Granada, etc. and wrote some interesting descriptions of the vegetation. The list of plants published by H. POLAKOWSKY represents the results of his botanical work in Costa Rica during 1875. BERNOUILLI collected in Guatemala during 1868—75. JOHN DONNELL SMITH botanized extensively in Central America and as a result printed Enumeratio Plantarum Guatemalensium etc. in eight parts, the last in 1907.

It is advantageous here to name those collectors and scientists, who, having travelled through Costa Rica, or established themselves there, have especially contributed to the knowledge of the natural resources of the country. They are A. PITTIER, A. S. OERSTED, C. HOFFMANN, H. POLAKOWSKY, M. WAGNER, Captain J. DONNELL SMITH, C. WARSCEWICZ, A. TONDUZ, P. BIOLLEY, A. VON FRANTZIUS, FRANC KUNTZE, W. M. GABB, Jose C. ZELEDON, ANASTASIO

ALFARO, JUAN J. COOPER, and Bishop BERNARDO AUGUSTO THIEL. GUSTAVO NIEDERLEIN in a pamphlet entitled The Republic of Costa Rica issued by the Philadelphia Commercial Museum gives an account of the character of the vegetation. Finally to KARL SAPPER, we owe much concerning the geology, physiography and plant geography of the Central American region.

## X. West Indies.

OVIEDO was apparently the first to describe the plants of the West Indies. Volumes VII—XI of his Primera parte de la historia natural y general de las Indias, Seville 1535, deal with the vegetation of the islands then known to the world. JOSÉ DE ACOSTA in the fourth volume of his Historia natural y moral de las Indias (Seville 1590) describes the natural history of the Island of Santo Domingo, Mexico and Peru. CATESBY follows with the Natural History of Carolina, Florida and the Bahama Islands published in two volumes at London in 1731—1743. The first important works were those of Sir HANS SLOANE 1696—1725 and of PATRICK BROWNE (1756) both on the flora of Jamaica. The collection of Sloane forms one of the treasures of the British Museum. PLUMIER's works 1693—1760 refer chiefly to Haiti. Enumerated his works are these:

1. Description des plantes de l'Amérique avec leurs figures. Paris 1693.
2. Nova plantarum americanarum genera. Paris 1703.
3. Catalogus plantarum americanarum. Paris 1703.
4. Filicetum americanum. Paris 1703.
5. Tractatus de filicibus americanis. Traité des fougères de l'Amérique. Paris 1705.
6. Botanicon americanum seu historia plantarum in Americanis insulis nascentium 8 vol. 1697—1704.
7. Botanographia americana, plantarum ex America icones 3 vol.
8. Antillarum insularum natur. icones bot. 1 vol.
9. Plantarum americanarum fasciculus primus(-decimus), continens plantas, quas olim Carolus Plumierius, botanicorum princeps, detexit eruitque, atque in insulis Antillis in ipse depinxit. Has primum in lucem edidit, concinnis descriptionibus et observationibus, aeneisque tabulis illustravit Joannes Burmannus. Amstelodami 1755—1760.

NICOLAUS J. JACQUIN published a number of works on the botany of the West Indian islands, viz., Enumeratio systematica plantarum in 1760 and Selectarum stirpium americanarum historia in 1763. — The name of OLOF SWARTZ is also prominently identified with the history of West Indian botany. He is best known, as the author of Nova genera et species plantarum seu "Prodromus descriptionum vegetabilium, maximam partem incognitorum quae sub itinere in indiam occidentalem annis 1783—87 digessit" (1788); and Flora Indiae occidentalis, etc. 3 vols. 1797—1806. SWARTZ was in Jamaica, Haiti and in a few of the lesser Antilles 1784—89.

Much less important are the publications of the first sixty years of the nineteenth century. TUSSAC's Flora Antillarum (1808—27) contains 138 colored plates of plants, many were collected in Haiti, others in the Island of Jamaica. LUNAN's Hortus Jamaicensis 1814 is a mere compilation and DESCOURTILZ'

Flore Medicale des Antilles (1821—29) is of little scientific value. HAMILTON's Prodromus Plantarum Indiae occidentalis (1825) is a pamphlet on certain new or doubtful species and MAYCOCK's Flora Barbadensis (1830) is a compendious list of Barbado plants. The Flora of Jamaica by MACFADYEN in two volumes appeared in 1837 and in 1850 respectively. A. RICHARD's Flora of Cuba (1838—53) compiled from RAMON DE LA SAGRA's and LINDEN's materials is incomplete. RAMON DE LA SAGRA's Flora cubana, ó descripcion botanica, usos, y applicaciones de Cuba, in four volumes Paris 1853 is an important work by the director of the botanic garden at Havana.

A. H. R. GRISEBACH, beginning with "Systematische Untersuchungen über die Vegetation der Karaiben" in 1857, published in English in 1864 his monumental work Flora of the British West Indian Islands, which has not been supplanted by any book up to the present 1908. Grisebach, also, is the author of Plantae Wrightianae e Cuba orientali 1860—62; Die geographische Verbreitung der Pflanzen Westindiens 1865 and Catalogus plantarum Cubensium exhibens collectionem Wrightianam, etc. 1866.

W. S. SULLIVANT published in the Proceedings of the American Academy of Arts and Sciences in 1861 his Musci Cubenses, or Mosses collected by CHARLES WRIGHT in the Eastern Part of the Island of Cuba during the years 1856, 1857 and 1858. Histoire des Fougères et des Lycopodiacées des Antilles Paris 1866 is by A. L. A. FEÉ in which a critical account is given of 722 pteridophytes. — The principal works of later date on the flora of the West Indies may be mentioned: TOMAS GONZALES Y DELGADO published in the annals of the Academy of Havana from 1867 to 1869, Apuntes para la Flora Cubana, a revision of the Cuban plants, cited by CAVANILLES. Fungi Cubenses by M. J. BERKELEY and M. A. CURTIS appeared in the Journal Linnaean Society of London in 1869; the original specimens being deposited in the Kew Herbarium. F. A. SAUVALLE published in 1873 at Havana his Flora Cubana of 324 pages and ALFRED BERNARD in an inaugural dissertation (Halle 1877) contrasts the flora of the west and east Indian archipelagos. The mosses of the French Antilles were described by E. BESCHERELLE in his Florule bryologique des Antilles françaises Paris 1876. DOMINGO BELLO Y ESPINOSO, who lived at Mayagüez from 1848 to 1878 published at Madrid in 1881—83, Apuntes para la Flora de Puerto Rico.

The name of Baron H. F. A. EGGERS is prominently identified with the botanic explorations of the West Indies. He published at least ten or eleven brochures dealing with Santo Domingo, the Bahamas, Puerto Rico, St. Croix and Tobago, but his Flora of St. Croix and the Virgin Islands, issued as a Bulletin of the United States National Museum in 1879, is the most important. — Dr. A. STAHL, whose plants are in the herbarium of Krug and Urban at Berlin, published from 1883—88 Estudios sobre la Flora de Puerto Rico. OSWALD READE printed at Hamilton, Bermuda in 1883 a book entitled Plants of the Bermudas, or Somers' Islands, and in 1884 JOHN HENRY LEFROY, the Botany of the Bermudas, as a Bulletin of the United States National Museum,

founded upon material desposited later in the Gray Herbarium at Harvard University, Kew Herbarium, London. The same year the Report on the Botany of the Bermudas and various other Islands of the Atlantic and Southern Oceans by W. BOTTING HEMSLEY appeared as Volume I, Part I Botany of the Challenger Expedition; so that the flora of these islands is well provided for by the several publications above mentioned.

In 1885 JOHOW's special morphologic studies entitled "Vegetationsbilder aus West-Indien und Venezuela", and "Die chlorophyllfreien Humusbewohner West-Indiens", saw the light. Flora arboricola de Cuba, aplicada of 118 pages by SEBASTIAN ALFREDO DE MORALES was printed at Havana in 1887. — Two works of importance to our knowledge of the algae of the Antilles appeared in 1888. One by F. HAUCK, published in Engler's Jahrbücher, is entitled Meeresalgen von Puerto Rico. The other is by GEORGE MURRAY, viz., Catalogue of the Marine Algae of the West Indian Region, printed in Britton's Journal of Botany.

The reports of the committees appointed for the purpose of reporting on the present state of our knowledge of the zoology and botany of the Bahamas and West India islands appeared in the several reports of British Association for the Advancement of Science beginning with 1888. The Provisional List of the plants of the Bahama Islands by JOHN GARDINER and L. J. K. BRACE arranged with notes and additions by CHAS. S. DOLLEY was published in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1889. WILLIAM FAWCETT in the Bulletin of the Botanical Department of Jamaica for 1889 gives a report on the flora of the Cayman islands and in 1893, he published a provisional list of the indigenous and naturalized flowering plants of Jamaica. MANUEL GOMEZ DE LA MAZA published in the annals of the Society of Natural History at Madrid from 1890—94 his Catálogo de las Periantiadas Cubanas, espontáneas y cultivadas.

G. S. JENMAN is the author of an important series of papers in the Bulletin of the Botanical Department of Jamaica 1890—98 entitled Synoptical List with descriptions of the Ferns and Fern-allies of Jamaica and of Ferns of the British West Indies and Guiana issued under the auspices of the botanic gardens at Trinidad. — List of plants collected in the Bahamas, Jamaica and Grand Cayman is the title of a report in the Fourth Annual Volume of the Missouri Botanical Garden (1893) of an expedition led by JOSEPH T. ROTHROCK to the West Indies. New Providence, Eleuthera, Cat, Watlings, Crooked, Fortune, Great Inagua, Jamaica and Grand Cayman islands were visited. The collected plants are in the herbaria at Philadelphia and St. Louis. — ROBERT COMBS published in the Transactions of the Academy of Sciences of St. Louis for 1897 a brochure on Plants collected in the District of Cienfuegos, Province of Santa Clara, Cuba in 1895. Johns Hopkins University circulars (1897) contain a report by W. K. BROOKS on the expedition to Jamaica in the summer of 1897 marked with fatality, for J. E. HUMPHREYS and Dr. CONANT died of fever, one in Port Antonio, the other in Boston. The plants of this expedition were collected by A. FREDHOLM and are deposited in the United States

National Herbarium at Washington. — F. BOERGESEN and OVE PAULSEN explored the Danish West Indies from an ecologic and phytogeographic standpoint and published their joint labors in a paper entitled Om Vegetationen paa de Dansk Vestindiske Oeer in 1898. This appeared in 1900 in a French dress under title of La Vegetation des Antilles Danoises, as an extract from the twelfth volume of La Revue Générale de Botanique. The Algae of Jamaica by FRANK SHIPLEY COLLINS is a paper printed in the Proceedings of the American Academy of Arts and Sciences in November 1901.

CHARLES FREDERICK MILLSPAUGH in the first volume of the Botanical Series of the Field Columbian Museum 1902 contributes a paper (No. 7) on the Flora of the island of St. Croix. Flora of New Providence and Andros is the title of a paper by ALICE R. NORTHROP in the twelfth volume No. 1 of Memoirs of the Torrey Botanical Club issued December 1902. J. W. HARSHBERGER, who made a botanic visit to Great Inagua, Haiti and Jamaica during the summer of 1900, has written two articles that deal with the phytogeography of those islands, viz., An Ecological Sketch of the Flora of Santo Domingo in the Proceedings of the Academy of Natural Sciences for 1901 and Notes on the Strand Flora of Great Inagua, Haiti and Jamaica in Torreya for May 1903.

*Symbolae Antillanae seu Fundamenta Florae Indiae Occidentalis* by IGNATIUS URBAN, which began to appear in 1898 has been continued since. The first volume contains an almost complete bibliography of West Indian botany a mine which has been drawn upon for many facts presented here. In June 1903, the Geographical Society of Baltimore fitted out an expedition to the Bahama Islands. The results, edited by George B. Shattuck with botany by WILLIAM G. COKER, appeared in 1905 in a volume of 630 pages entitled the Bahama Islands.

Unusual activity has recently been shown by American botanists in the study of the West Indian flora. D. H. CAMPBELL, D. T. MAC DOUGAL and DUNCAN S. JOHNSON have visited Jamaica. F. S. EARLE visited the islands of Jamaica and Puerto Rico where he went in the interests of plant mycology. G. V. NASH was sent to Haiti by the New York Botanical Garden. LUCIEN M. UNDERWOOD has been in Jamaica to study its fern flora, N. L. BRITTON has visited St. Kitts and the islands of Cuba, Jamaica and the Bahaman archipelago, and MRS. BRITTON has made large collections of Cuban mosses. FRANCIS E. LLOYD and MRS. LLOYD have botanized in the Island of Dominica and MARSHALL A. HOWE has been to the Bermudas and Puerto Rico to study the marine algae. A tropic research botanic laboratory has been established at Cinchona in the Blue mountains of Jamaica under the auspices of the New York Botanical Garden, which institution has begun the publication of a Flora of the whole of North America. Another research station has been started at Bermuda under the charge of the scientists of Harvard University and the University of the City of New York. The first session was held during the summer of 1903.

The above historic summary does not claim to be complete. The most salient facts have been chosen, which illustrate the development of knowledge

of the several phytogeographic regions of North America. The title of the most important papers, named or omitted from the accompanying history, will be given in the bibliography which follows in list form with more complete bibliographic details, than has been possible in the historic account. The attempt has not been made to furnish a complete synopsis of the literature dealing with the phytogeography of North America [1].

## § 2. Plant Geography.

### 1. General.

No general work solely devoted to the plant geography of North America has ever been published. The only work of a general nature, which may be said to offer any satisfactory information on this important subject, is a recent pamphlet by A. ENGLER entitled: *Die pflanzengeographische Gliederung Nordamerikas erläutert an der nordamerikanischen Anlage des neuen königlichen botanischen Gartens zu Dahlem-Steglitz bei Berlin, mit einer Verbreitungskarte und einem Orientierungsplan*, issued in 1902 as Notizblatt des königlichen botanischen Gartens und Museums zu Berlin, Appendix IX. Several works, however, ought to be mentioned as of especial phytogeographic significance, viz., Statistics of the Flora of the Northern United States by ASA GRAY in American Journal of Science for 1856; The Botany of the United States Geological Exploration of the Fortieth Parallel under CLARENCE KING by SERENO WATSON and D. C. EATON 1871; ROBERT BROWN's article in the Proceedings of the British association for 1871 on the geographic distribution of the floras of northwest America; ROTHROCK's Botany of the Wheeler Survey 1874; Die Florengebiete Nordamerikas by BRENDEL, noticed in Botanischer Jahresbericht 1874; *Die Waldungen von Nordamerika*, by H. MAYR 1890.

In the Transactions of the Academy of Sciences of St. Louis for 1877 GEORGE ENGELMANN contributed a paper on the Geographical Distribution of the North American Flora. The following papers by ASA GRAY, collected by SARGENT in the Scientific Papers of Asa Gray, must be consulted by any earnest student of the American flora: Sequoia and its History; Forest Geography and Archaeology; The Flora of North America and Characteristics of the North American Flora, which appeared in Nature for 1885. In conjunction with J. D. HOOKER was issued the Vegetation of the Rocky Mountain Region, and a Comparison with that of other Parts of the World 1881. Tenth Census Report on the Forests of North America with volume of maps by CHARLES S. SARGENT 1884; In 1881 appeared an account in the Report of Canadian Geological Survey (1879—80) of the northern limit of American forest trees with map.

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1) Auf besonderen Wunsch der Herausgeber hat Prof. Harshberger die ursprünglich ausführlicher gehaltene Liste der floristischen und pflanzengeographischen Literatur noch beschränkt, wie es auch in den anderen Bänden der V. d. E. gebräuchlich ist. (Drude.)

GRISEBACH's Die Vegetation der Erde in two volumes 1884 contains much of interest. Atlas der Pflanzenverbreitung by DRUDE contains a map of North American plant regions. DRUDE's Handbuch der Pflanzengeographie 1890 should also be consulted, as also ENGLER's Versuch einer Entwicklungsgeschichte der Pflanzenwelt (1879). MERRIAM's Geographic Distribution of Life in North America printed in Annual Report Smithsonian Institution (1891) is historically important. The Metaspermae of the Minnesota Valley by CONWAY MACMILLAN 1892 is invaluable. COVILLE's Botany of the Death Valley Expedition 1893 is an important work for the desert region. Pflanzengeographie auf physiologischer Grundlage by the late Dr. A. F. W. SCHIMPER 1898 is a fine reference book for many interesting details. Life Zone and crop Zones by MERRIAM 1898 was issued as a bulletin of the United States Biological Survey. KEARNEY's Report on a Botanical Survey of the Dismal Swamp Region 1901 is important. The Phytogeography of Nebraska by POUND and CLEMENTS 1900, Plant Life of Alabama by CHARLES MOHR 1901 and Flora of Washington by C. V. PIPER 1906 about complete the list of the most important works on the phytogeography of North America.

## 2. Physiography and Soils.

The number of separate monographs papers and books on the physiography, soils and geology of North America is too vast to present even in an abbreviated form in this section. Only those publications will be mentioned which seem to be especially useful for consultation in connection with phytogeographic work. The study of North American physiography (physical geography) and geology has gone hand in hand, but a detailed and scientific study of the superficial soil formation is of comparatively recent date. The Geological Survey of the United States publishes both bulletins, monographs and annual reports and a series of topographic and geologic maps which are intended to cover finally the entire territory of the United States. These have been frequently consulted in the preparation of this volume. The variety of topics which must be considered by the plant geographer is indicated in the following titles. The causes which have led to the production of Cape Hatteras by N. S. SHALER in the Proceedings of the Boston Society of Natural History for 1872 is a sample. Lakes and Valleys in Northeastern Pennsylvania is the title of an article by WM. M. DAVIS, in first volume of the National Geographic Magazine. ROBERT T. HILL contributed to the American Geologist in 1890 (9, 65) a paper entitled Classification and Origin of the Chief Geographic Features of the Texas Region and an article on The Making of Pennsylvania is suggestive.

The first report of the United States Board on Geographic Names was printed by the government in 1891. E. W. HILGARD furnishes an account of the physical and industrial geography of California to the Geographical Journal of 1893. The National Geographic Magazine for 1894—95 contains a valuable contribution on the Geomorphology of the Southern Appalachians

by CHARLES W. HAYES and M. R. CAMPBELL. However, the most important series of pamphlets on the physiography of North America appeared as National Geographic Monographs prepared under the auspices of the National Geographic Society in 1895. Ten of these monographs by J. W. POWELL, N. S. SHALER, I. C. RUSSELL, BAILEY WILLIS, C. WILLARD HAYES, J. S. DILLER, W. M. DAVIS and G. K. GILBERT have been issued and are replete with interest to the phytogeographer.

Three volumes of STANFORD'S Compendium of Geography deal with North and Central America. North America is represented by two volumes one on Canada and Newfoundland by SAMUEL EDWARD DAWSON published in 1897 and a second by HENRY GANNETT on The United States (1898). — The second volume of two devoted to Central and South America deals with Central America and West Indies by A. H. KEANE published in 1901. The handbooks dealing with the Central American countries issued under the auspices of the U. S. Bureau of American Republics have been found extremely useful, as reference texts, as also the publications of the Philadelphia Commercial Museum on Costa Rica, Nicaragua and Guatemala. — For the West Indies, ROBERT T. HILL'S book Cuba and Porto Rico with the Other Islands of the West Indies 1898 has been frequently consulted. GANNETT'S Dictionary of Altitudes in the United States (third edition), published as bulletin 160 (United States Geological Survey) in 1899, is a useful compendium of important data and the second report of the United States Board on Geographic Names published in 1900 was at hand for reference. — The articles of CARL SAPPER, as an authority on the physiography of the Central American States, are invaluable for the states of Guatemala and Honduras. These appeared in German journals in 1895 and 1902 respectively.

For details of American physiography must be mentioned in closing an article by MCGEE in the National Geographic Magazine 1896 on the Geographic History of the Piedmont Plateau. The Topography of California by NOAH F. DRAKE appeared in the fifth volume of the Journal of Geology. G. K. GILBERT contributed in 1898 to the National Geographic Magazine an important article on the Origin of the Physical Features of the United States and in the Journal of Geology for 1903. A. W. G. WILSON discusses the Laurentian peneplain. The Topography of Mexico is an important article by HERBERT M. WILSON in the Bulletin American Geological Society for 1897. Notes on the Drainage of the Pennsylvania Appalachians by W. M. DAVIS was printed by the Boston Society of Natural History in its twenty-fifth volume. G. M. DAWSON published in Popular Science Monthly (XXXVIII: 353) an article entitled Later Physiographic Geography of the Rocky Mountains in Canada. The Age of the California Coast Range by W. H. FAIRBANKS and published in the eighteenth volume of the American Geologist is an important one to plant geographers. C. WILLARD HAYES contributed to the Bulletin of the Geological Society of America (X: 285) a paper with the title Physiography and Geology of the Region adjacent to the Nicaragua Canal Route. — A book

must be mentioned now which is destined to play an important part in advancing our knowledge of the physiography of the northeastern United States. Reference is made to The Physical Geography of New York State by RALPH S. TARR published in 1902 in 397 pages and many illustrations. For the northern Appalachians and the region of the Great Lakes and glacier covered districts of North America this book is indispensible. Finally FENNEMAN'S Lakes of Northeastern Wisconsin published by the Wisconsin Geological and Natural History Survey throws important light on the lake district of Central North America.

As geologic reference texts the phytogeographer should consult two books. Manual of Geology Treating of the Principles of the Science with special Reference to American Geological History by JAMES D. DANA (fourth edition 1895) and Text-Book of Geology by SIR ARCHIBALD GEIKIE (1893), These books do not exhaust the list of important works on American geology, which comprise bulletins, monographs and books of special import, such as WRIGHT'S Ice Age in North America 1891. Nearly all of the eastern and southern United States have supported at one time or another an agricultural survey in which the general character of the soil has been recognized and described. This information is scattered through a great number of reports on agriculture and geology, many of them dating in the early part of the nineteenth century. Maps have been published also, representing the general distribution of soil types, but as the results lack cohesion and definite plan, they are not tangible. — The United States Department of Agriculture to meet the demand for a more accurate soil survey inaugurated the Division of Soils connected with which there is a laboratory of soil physics and a laboratory of soil chemistry for considering and investigating the many problems which press for a solution. Parties in the field supply the data with which maps are plotted. So far as possible, the topographic sheets of the United States Geological Survey are used as base maps for soil work. — The results of the laboratory and field work have appeared in a series of twentytwo bulletins 1895—1903 which give important material that can be utilized by the botanist. The maps are published in conjunction with the reports on the field operations of the Division of Soils. Reports beginning with that for 1899 have been printed, one volume of text and one of maps and plates. These are indispensable to the plant geographer and plant ecologist as well as vegetable physiologists. In addition to these useful reports and bulletins should be mentioned a paper in the Yearbook of the United States Department of 1895 on the origin, value and reclamation of alkali lands. HILGARD'S book on Soils 1906 with important chapters on soils and native vegetation supplements the earlier reports of HILGARD and LOUGHRIDGE on the soils of the cotton region. The Vegetation of the Bay of Fundy Diked Marshes by W. F. GANONG appeared in the Botanical Gazette for 1903. The British Association committee report upon the depth of permanently frozen soil in the Arctic region has a direct bearing upon the flora of the northern tundras.

## 3. Altitudinal Distribution.

The papers that deal with the altitudinal distribution of plants in North America are comparatively few in number.

For the White Mountains, we have the List of Plants found in New Hampshire only on Alpine Summits by C. H. HITCHCOCK and published in his report on the geology of New Hampshire in 1874. J. W. CHICKERING contributed to Field and Forest (1876) a Catalogue of the Alpine and Subalpine Flora of the White Mountains and C. G. PRINGLE the same year, an article to the American Naturalist on the alpine and subalpine plants of Vermont. "Among the Clouds" for 1900 gives a list of alpine plants of Mt. Washington made by the Appalachian Club. The alpine flora of Mt. Katahdin has been investigated by the New England Botanical Club, L. H. HARVEY, the results of whose labors appear in the fifth and third volumes of Rhodora, and by an ecologic party under the leadership of H. C. COWLES of the University of Chicago, while the ascent of the same mountain by J. W. HARSHBERGER is described in the fifth volume of the Plant World. The Bulletin of the Torrey Botanical Club for 1890 gives an account of the flora of Mt. Monadnock by WALTER DEANE. Plants of the Summit of Mt. Marcy, one of the few alpine peaks in Adirondack mountains, is the title of an article by CHARLES H. PECK in the Bulletin of the New York State Museum for October 1899. For the mountains of the southern states, the list is even smaller, a paper by J. W. HARSHBERGER on the ecology of mountainous North Carolina published in the Botanical Gazette for 1903, one by PINCHOT and ASHE on the forests and one on the altitudinal distributions of ferns with several shorter papers by JOHN K. SMALL practically completes the enumeration. The mountains of the western United States and of Mexico have been investigated to some extent. THOMAS MEEHAN, T. S. BRANDEGEE and HENRY GANNETT have contributed to the Botanical Gazette articles on the timber line of high mountains. As bulletins of the North American Fauna we have contributions of this subject in the results of a biological survey of Mount Shasta, California (1899) and of the San Francisco mountains (1890) by C. HART MERRIAM.

The Rocky Mountain alpine region has been investigated by C. C. PARRY and T. D. A. COCKERELL the latter publishing a paper in the Bulletin of the Torrey Botanical Club on the flora of high altitudes in Custer County, Colorado. Zonal Distribution of Trees and Shrubs in the Southern Sierra is the title of a paper by WILLIAM R. DUDLEY in the Sierra Club Bulletin for 1901, and a Botanical Survey of San Jacinto Mountain is a monograph by HARVEY MONROE HALL, printed as one of the University of California publications for 1902. Vegetation sobre las Altas Montanas de Mexico published in La Naturaleza 1887 by H. DE SAUSSURE.

The Temperate and Alpine Floras of the Giant Volcanoes of Mexico by ANGELO HEILPRIN 1892, Über die untere Niveaugrenze des Eichen- Kiefernwaldes am Vulkan von Colima by E. KERBER 1882, Vegetation des Piks von

Orizaba by LIEBMANN in Botanische Zeitung 1844 are publications dealing with the alpine summits of the high mountains of Mexico. Papers which are more or less physiographic in character throw important light on the subject here discussed. — Die Hochketten des nordamerikanischen Felsengebirges und der Sierra Nevada by Dr. EMIL DECKERT is one published in Zeitschrift der Gesellschaft für Erdkunde zu Berlin in 1901. Höhenmessungen im Colorado-Territorium und die Baumgrenze in den Felsengebirgen appeared in PETERMANN's Mittheilungen in 1866 and Observations on Popocatepetl and Ixtacihuatl is a bulletin of the Field Columbian Museum by OLIVER C. FARRINGTON, issued April 1897.

## 4. Phenology.

Phenologic observations have been pursued systematically abroad. Although the importance of the subject has long been recognized by American botanists the observations have been made sporadically so that American records lack that continuity and completeness which many European ones show.

Phenologic observations in Canada have been made by A. H. MCKAY, who brought them together in the Proceedings of the Nova Scotia Institute of Science for 1897 and in the eight volumes of the Canadian Record of Science. H. C. IRISH published some valuable tabular and graphic records in the Fortieth Report Missouri State Horticultural Society 1898 in a paper, entitled Comparative Phenological Notes and later in the American Naturalist for 1900. Sporadic records have appeared in several of the earlier volumes of the Bulletin of the Torrey Botanical Club from the pens of N. L. BRITTON and L. H. PAMMEL the latter also writing a paper for the monthly Review of Iowa Weather and Crop Service, October 1891 on climate and plants. The Botanical Gazette in its earlier volumes should be referred to for phenologic data furnished by W. W. BAILEY for Rhode Island, by T. S. BRANDEGEE for Colorado, and others. CROZIER published a pamphlet in 1885, called The Modification of Plants by Climate which has been frequently quoted. One of the earliest American expressions upon phenology was made by FREDERICK BRENDEL of Illinois, who, in comparing the late spring of 1857 with the very early spring of 1859, found in some species a striking coincidence of the sums of the mean temperature and of the number of days on which the temperature rose above freezing point. In his Flora Peoriana (1887) he extended his views. E. W. HERVEY published at New Bedford in 1860 his Catalogue of the plants of New Bedford arranged phenologically. HALSTED also has made observations on the data of blossoming of the early prairie flowers and has published them in the Popular Science Monthly (XXXI: 85). Meehan's *Monthly* for June 1894 contains the phenologic records of EDWIN JELLETT. The Philadelphia Public Ledger for 1896 and 1897 contains lists of plants collected by members of the Philadelphia Botanical Club with dates of flowering and fruits. Although these lists are not primarily phenologic, yet they are useful in determining the approximate dates of two important phases of

plant development. In line with these is DARRACH's Plants appearing in Flowers in the Neighborhood of Philadelphia February to November 1883.

The general works on American phenology are few. Modern Meteorology by WALDO, published in 1893, contains an important resumé. The Advent of Spring an article by MARK W. HARRINGTON, which appeared in Harper's Magazine in May 1894, describes the advance of the southern wave of 43.8° F. northward across United States, when Spring may be said to begin. CHARLES ROBERTSON contributes to the twenty-ninth volume of the American Naturalist, a paper entitled the Philosophy of the Flower Seasons and the Phaenological Relations of the Entomophilous Flowers and the Anthophilous Insect Fauna, and HENRY CLARKE to the twenty-seventh volume of the same journal (1893) the Philosophy of the Flower Seasons, while J. W. HARSHBERGER contributed to Science an article on the origin of the vernal flora. Instructions for taking Phenological Observations by L. H. BAILEY was abstracted from Monthly Weather Review for September 1896, while the same botanist devotes two chapters to a phenologic discussion in his book, the Survival of the Unlike. These Chapters were the outcome of a paper prepared for the Weather Bureau *United States Department of Agriculture entitled Some Suggestions for the* Study of Phenology. He gives speculative note on phenology the interrelations of climatology and horticulture while a chapter is devoted to acclimatization. The field work of the Division of Biological Survey of the U. S. Department of Agriculture is based on the publications of C. HART MERRIAM, who founded his system on the laws of temperature control of the geographical distribution of terrestrial animals and plants, essentially phenologic data. Finally should be mentioned the excellent records kept by members of the Botanical Society of Pennsylvania. These incorporated with those kept by RAND of Radnor, Pa. for a long series of years have been correlated and classified for future reference use.

*It is clearly evident, therefore, that the American literature on phenology* is very meagre and that the so called phenologic observations have been mere records of dates of blooming of flowers, leafing of trees, migration of birds, peeping of frogs and the like, without much correlative data respecting the local climate.

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# Chapter II. Bibliography.

The titles in the following lists are arranged first geographically and then alphabetically according to the names of the authors as the most convenient method of displaying the names of books and papers upon the North American flora. The titles of a number of works, or monographs, which deal with the physiography, geology and geography of the several regions are also included, so that the following enumeration, very restricted as it is, yet gives the more

important books which have been instrumental in the writing of this book. As this book is merely an introduction to the phytogeography of North America, many titles have been omitted purposely from the bibliography, because they will come naturally into prominence in the preparation of special volumes on North American flora, which are designed to follow the publication of this volume.

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# Part II.

# Geographic, Climatic and Floristic Survey.

## Chapter I. Geographic Character of North America.

### 1. General Survey of the Continent.

North America, excluding Greenland and Ellesmere Land, extends from Point Mariato on the Isthmus of Panama in 8° N. latitude to North Cornwall Island 77° N. latitude, and lies between 56° west longitude, that of Cape Race Newfoundland, and 170° W. longitude, that of St. Lawrence Island, Pribilof islands and the island of the Four Mountains, belonging to the Aleutian Island chain, the westernmost of which west of the 170° of west longitude are excluded from consideration. The coast line of such a large portion of the earth's surface is most irregular and highly diversified. Some portions of it represent physiographically a raised shore line, other parts of it have been depressed and may be considered to be drowned, as evidenced by deep fjords and numerous outlying islands. The main continent, which is approximately rectangular, projects southward in three prolongations, viz., the Florida peninsula, the Mexican and Central American isthmus and the peninsula of Lower California. Each of these is different in its physiographic construction. Mexico and Central America are essentially continental, while the peninsula of California occurs, as a prolongation of a drowned coast, while Florida represents a part of a region of active land formation. Four coastal plains may be distinguished, viz., the Pacific, the Arctic, the Atlantic and the Gulf. These are drained by numerous rivers, some of great size, which rise inland and flow to the sea. The Pacific coastal plain is characterized by the short length of its drainage streams and the comparatively small volume of water carried by these, with the exception of the Columbia River, which empties into Puget Sound.

The principal physical features of the continent in addition to the plains mentioned are very simple. There are two systems of mountains, one near the eastern coast, the Appalachian system, which trends parallel to the coast, that is, nearly, north-east and south-west and is of little elevation and breadth compared with the other. The other is the Cordilleran system, which stretches from the Isthmus of Panama to Bering Sea and has its greatest

development in the United States. Between the two is a broad basin drained by the Mississippi River, the Great lakes, the Mackenzie River and streams that debouch in Hudson's Bay.

The Cordilleran system may be divided into the Rocky mountain ranges, the Sierra Nevada ranges and the Coast ranges, which penetrates Mexico reaching to the Isthmus of Tehuantepec. South of Tehuantepec, the mountain system, although in part continuous with the cordilleras of the north, may yet be looked upon as distinct, for it runs almost due southeast and east, and in Yucatan the mountains trend in the same general direction, as those in the greater Antillean islands, viz., Cuba, Jamaica, Santo Domingo and Puerto Rico, and may be called the Antillean orographic system. East- and west-mountain ranges of the Antillean type occur through the Greater Antilles, along the Venezuelan and Columbian coast of South America, north of the Orinoco, in the Isthmus of Panama, Costa Rica, and the eastern parts of Nicaragua, Guatemala, Honduras, Yucatan, Chiapas and southern Oaxaca. The two elongated submarine ridges, separated by the deep oceanic valley known as Bartlett Deep, which stretch across the Caribbean from the Antilles to the Central American coast, from the west end of the Sierra Nevada range of Cuba to the coast of Honduras, and from Jamaica to Cape Gracias a Dios, respectively, are similar in configuration to the east-and-west mountain ranges of the Great Antilles, and are, no doubt, genetically a part of them.

The Gulf of Mexico is an indentation into the North American continent, the restricted survival of a great interior sea, which once extended over the Mississippi plain region of the United States, which at one very old time, almost, if not entirely, separated North America into two great continents, the Appalachian and the Cordilleran. The basin of the Gulf is still filling up with the material brought down by rivers, which drain nearly one fourth of the area of the United States. With the single exception of its extreme southwestern indentation upon the coast of Mexico, the Gulf is surrounded by low plains.

The Atlantic coast has, on the whole, a tolerably straight course in a direction nearly south-west; but in detail, it is greatly indented with numerous deep bays and harbors, and fringed by many islands. The north-eastern coast is rocky with deep fjord-like bays, and islands formed by depression of a more extended coast-line. South of and including Cape Cod, the character of the coast changes to a low sandy shore, and this character is maintained thence southward and around the Gulf. Along this part of the coast extends a line of narrow, linear islands, which are sand-bars thrown up by the waves, behind which are many shallow bays and salt marshes. The Pacific coast is much less indented. It is very abrupt, rising from the shore for thousands of feet to the summits of the coast mountains and descending beneath the surface abruptly to great depths. It has few harbors San Francisco Bay, Puget Sound and Gulf of California being the largest ones. The Alaskan coast resembles in many ways that of New England, but its features are on a much larger

scale. It is rugged and rocky, fringed by thousands of mountainous islands with numerous fjords constituting excellent harbors.

North America, as a continent, is best considered in four divisions. The most southern consists of Mexico and Central America. East of this lies the second division comprising the Greater Antilles and the Bahama islands. The central division consists of the United States (3,022,980 square miles = 7,829,518 qkm). The northern division consists of the Dominion of Canada, Alaska and the island of Newfoundland (4,170,973 square miles = 10,802,820 qkm).

## 2. Northern Division.

*The Northern Plains.* The Barren Grounds is a region west of Hudson Bay. It is a treeless wilderness low and marshy interspersed with lakes, streams and mossy plains, the socalled arctic tundra. The soil is permanently frozen to a great depth and in summer it thaws out a foot, or two, to permit the grasses, sedges and other plants of the region to make a rapid vegetative growth. If a line be drawn from the western shore of Hudson Bay north of Fort Churchill, along the 60th parallel of latitude and curve to the north-west to cut off the eastern arm of Great Slave Lake, and, thence, northward through Great Bear Lake and down Lockart and Anderson rivers to the Polar Sea, such a line will approximately inclose the Barren Grounds on the north. In general it includes the river valleys east of the Mackenzie River, which discharge directly into the Arctic Ocean and those north of the Churchill River, which discharge into Hudson Bay. This region drains mostly to the north by the Coppermine and the Great Fish (Back's) rivers, consisting of strings of lakes connected by violent rapids, and flowing for the most part in rocky channels. The Barren Grounds for the most part occupy the area of Laurentian rocks.

The arctic coast always protected by masses of ice is uniformly low and is bordered by low cliffs of frozen clay and sand, or eastwards, as far, as Coronation Gulf by limestone. North of the continent is the immense arctic archipelago. All the islands consist geologically of late formations from Silurian to Carboniferous. Along the coasts of Melville Sound and M'Clure Strait are abundant deposits of bituminous coal close to the immovable barrier of ice. The coasts of them are high and often precipitous. Parry found that an impenetrable ice pack surrounded the islands to the north of the continent. The ice of the polar sea north of America is more formidable than that in the Spitzbergen. It is probably entangled in an archipelago extending far to the north. From accounts, it does not consist of bergs, the product of glaciers, but of immense fields of hard, blue ice, sometimes four miles in diameter with hummocks twenty to forty feet high and united by the action of the winds into packs of immense extent.

The coast of Alaska west of Demarcation Point is low with cliffs of frozen sand and clay. Point Barrow is low and the northern ice-pack rests against it for the greater part of the year. Not far inland, a chain of mountains follows the outline of the coast. Mackenzie Bay is one hundred and sixty miles (257 km)

across. The Mackenzie River discharges into it with a great volume through a delta of intricate channels. Eastward along the arctic shore from the mouth of the Mackenzie, the coast is low consisting of soft rocks of the Cretaceous formation. An interruption of Devonian limestone occurs at Cape Parry from whence a long stretch of Cambrian rocks follows the shore to the eastern end of Coronation Gulf and Dease's Strait, excepting Cape Barrow, which is Laurentian, and a cliff 1500 feet (456 m) high. This part of the coast is bold and high.

With one exception (the Mississippi), the Mackenzie River is the largest in North America. It rises on the eastern slopes of the Rocky Mountains in the Yellow-head and Athabasca passes. The Peace and the Liard rivers are two of its great tributaries, while on the east, it receives the waters impounded by the Athabasca, Great Slave and Great Bear lakes. It is separated from the basins of the Churchill and Saskatchewan rivers by narrow and low water-partings. The Mackenzie valley is an alluvial plain bounded on the east by a more or less wooded region drained by the Coppermine and Great Fish rivers; on the west, it is limited by the Rocky Mountains and on the south by the divide of the North Saskatchewan. The soil is deep and well suited to the growth of crops wherever the climate permits. The elevation of the valley is very slight. Lake Athabasca is 690 feet (210 m) and Great Slave Lake in 391 feet (119 m) above sea level.

The Mackenzie river basin forms the northern portion of the great interior plain continuous with that of the United States. In the Dominion of Canada, it comprises the provinces of Mackenzie, Athabasca, Saskatchewan, Assiniboia, Manitoba and Alberta. The chief characteristic of the area is that of an immense ocean-like plain, treeless at the south, but gradually becoming forest-clad at the north. This plain slopes with a very gentle descent to the north. The initial elevation is slight and the distance to the oceans, whether of the north, or east, is great, hence the rivers flow over an almost level peneplain with a tranquil current and the low divides between adjacent waterways is a feature of the country. Two lines of elevation divide the plain into three parts called by physiographers the first, second and third prairie steppes, ascending from Lake Winnipeg to the Rocky Mountains. The region of the first steppe in quaternary time, geologists show, was covered by an immense glacial lake designated "the glacial Lake Agassiz". It extended far into Minnesota and included all the basin of the Red River of the North and the basins of lakes Winnipeg, Manitoba, Winnipegoosis, Dauphin and Lake of the Woods. The outlet toward the north was blocked by an ice cap and all the water drained southward into the Mississippi River. As the ice melted, outlets were opened to the north and the lake level was lowered. The water withdrew into the lowest depressions and the existing lakes assumed their present proportions.

The hard crystalline Laurentian rocks extend to the eastern shore of Lake Winnipeg. These are bordered on the west by a belt of Silurian and Devonian

limestones. These limestone formations reach the Arctic Sea in a north-west direction, but form the western shore of Lake Winnipeg and extend along the other lakes to the west. Upon these rest the comparatively soft rocks of the Cretaceous and Laramie formations, which characterize the area of the great interior plain and these are in turn covered by thick deposits of glacial drift (clays, sands, silt and gravels) upon which the nature of the superficial soil depends.

The Red River of the North is an important stream flowing from its source in the State of Minnesota and falling into Lake Winnipeg through a swampy delta. Its chief tributary is the Assiniboine, which flows in its 350 mile (573 km) course through some of the most fertile land in the north-west. North of these flow the Saskatchewan with its affluents (1032 miles long = 1660 km) rising in the heart of the Rocky Mountains and emptying into Lake Winnipeg, which disposes of its surplus waters to Hudson's Bay through the Nelson River. The country is one of numerous lakes. Lake Winnipeg the largest is 260 miles (418 km) long, 5 to 65 miles (8—105 km) in breadth, and 42 to 90 feet (13—27 m) deep.

Hudson Bay is an immense navigable inland sea extending half way across the continent at its widest part. The depth of the water in the bay averages 70 fathoms, excepting near the strait, where it deepens to 100 fathoms. The water of James Bay is brackish, where as in Hudson's Bay proper, the water is as salt, as in the main ocean. The tidal wave enters at the strait and first strikes the western shore. It rises 11 to 12 feet (3—4 m) at Churchill and in the converging shores of the estuary of the Nelson River, it rises 15 feet (5 m), but as the tide passes round the coast to the south and east, it becomes lower. Cape Wostenholme is 2000 feet (608 m) in elevation and from it the land falls southward to a low and level coast, as far, as Cape Dufferin, where it again rises to 1000 feet (304 m) to continue round the entire basin in a coast line of low relief. The rivers draining into it from the east are the Nastapoka, Great Whale and Little Whale. The East Main River by one branch approaches Lake Mistassini and by another branch reaches far into the heart of Labrador.

The peninsula of Labrador, located between the Atlantic Ocean and Hudson Bay, may be described as a tableland having a general elevation of 1500 to 2000 feet (456—608 m) above the sea. The plateau rises abruptly from the Atlantic Ocean in stupendous cliffs increasing in height towards the north. The shore of Ungava Bay is low, but toward Cape Wostenholme, the shore again rises. The eastern shore of Hudson Bay is low excepting between Portland promontory and Cape Jones, where a range of mountains approaches close to the coast. The plateau is drained by a number of important rivers, which usually hurry down in swift continuous rapids and precipitous falls. The Laurentide Mountains mark the boundary of southern Labrador. The streams rising on the south slopes of these mountains flow into the St. Lawrence River and Bay. Another group of rivers empty into Hudson Bay, while still

a third group drain north-ward into Ungava Bay and the fourth drainage area is represented by the basin of the Hamilton River 600 miles (965 km) long which debouches into the Atlantic Ocean. The largest lake of Labrador is Mistissini, very deep and 100 miles (161 km) long. — Geologically Labrador is an immense area of Archaean rocks. Ninetenths of the peninsula consists of Laurentian gneisses with instrusions of granite, basalt and syenite.

Newfoundland, southeast from Labrador, is an island one third larger than Ireland. The western coast of the island is comparatively straight, but the southern and eastern coasts are profoundly indented with deep fjords, providing safe harbors and numerous headlands, or promontories jut out into the ocean. The general character of the coast is very rugged and bold. A rampart of cliffs, 200 to 400 feet (61—122 m) high, resists the storms of the North Atlantic. The west coast, a few miles inland, is characterized by the presence of the Long Range Mountains, rising in places 2000 feet (608 m), and running far into the Petit Nord peninsula. The south coast of Newfoundland is studded with islands and islets. The most important rivers are the Humber, emptying into the Gulf of St. Lawrence, Exploits River, emptying into Notre Dame Bay, and Gander River, emptying into the Atlantic Ocean. Newfoundland geologically may be divided into an arca of Huronian rocks occupying the south-east corner and the peninsula of Avalon, and an area of predominant Laurentian rocks found over the remaining two-thirds of the island. The Long Range mountains are entirely Laurentian. While the core of the island is Archaean, there are large areas of later formations, such as Carboniferous, Cambro-Silurian. Upper Silurian, and upon these are the agricultural and heavily timbered lands. A large part of the interior remains unexplored and no white man, since Cormack in 1822, is reported to have crossed the main island in its greatest extension on foot.

The Alaska coast of Bering Sea is mainly low and marshy, rising very gently inland, and consisting almost entirely of tundra. The Yukon, the great river of Alaska and one of the great rivers of the earth, has a delta which covers thousands of square miles and across which the forking ends of the river run. Where the Alaskan coast faces the Pacific, it is bold and rugged; where it faces Bering Sea, it is low and tundra-clothed. North of the Yukon most of the land is permanently frozen to a great depth, some-times not even thawing in July. The coast of south-eastern Alaska is a broken one, and is bordered by many large and small islands, forming an archipelago. The channels separating these islands are deep and tortuous and from them the shore rises precipitously. Deep fjords cut the coast-line and extend far inland. A chain of islands stretches westward to longitude 187° known as the Aleutian islands. Most of them are volcanic and are simply the tops of submarine mountains.

*The Pacific Range.* The Cordilleran system of mountains, which is broad in the United States, narrows northward, as it stretches through British Columbia, and enters Alaska very much contracted in breadth. Following the

Pacific coast in its windings, the main body of this mountain system occupies the Alaskan peninsula, disappearing in the sea at the extremity of the mainland. All of southeastern Alaska is a mountainous region, culminating in Mount St. Elias on the coast, at an elevation of 18,100 feet (5516 m [1]), and the recently discovered Mount McKinley 20,467 feet (6238 m) high. Mount McKinley is of granite weighted down with not less than fifty disconnected glaciers with everywhere precipitous walls. The mountains of Alaska, especially those about Mount St. Elias and thence south-eastward, are covered with great glaciers prominent among which is the Malaspina, with its feeders Agassiz, Seward, Marvine and Hayden glaciers. Muir Glacier is also a noted one at the head of Glacier Bay. Volcanoes active and extinct also occur in Alaska, and the evidence of former volcanic activity is witnessed by portions of the entire peninsula. Northward from the higher ranges Alaska descends in a succession of lower ridges to the valley of the Yukon.

The Yukon River, 2000 miles (3218 km) in length, rises in British Columbia, flows north-west with a very sinuous course with rapids and deadwater to the Arctic Circle. There it is joined by the Porcupine, one of its largest branches and finally after many turnings, it empties into Bering Sea. It is a broad muddy stream full of shoals and rapids. Other large rivers drain the country. One of the characteristics of Alaska is the network of rivers that covers its surface. The Copper, the Tanana, the Sushitna, the White and Kuskokwim are prominent rivers. On the south, the Stikine is the first river of large size rising in British Columbia.

British Columbia including Vancouver Island is the Pacific province of the Dominion of Canada. The physiography of the country is exceedingly complex. The rivers, abrupt in their turns are swift and turbulent. The lakes are narrow and deep. Two great physical features make up the topography of British Columbia, viz., the Rocky Mountains and the Coast Mountains. The Rocky Mountains are continuous with mountains of the same name in the United States. Their elevation is greatly reduced at the Peace River, but as they run northward, they rise again and parallel the western edge of the Mackenzie River valley, until they run out as they approach the Arctic Ocean. The Coast, or Cascade range commences at Puget Sound and continues along the Pacific coast to the head of Lynn Channel. It is this range which gives the precipitous character to the sea coast with its deep fjords and land-locked harbors.

Rising from a region of foot-hills 20 miles (32 km) wide, formed by the folding of the strata, the Rocky Mountains present from the east an abrupt and serrated outline against the sky, revealing by their sharp summits their recent geologic age. This range is the latest formed of all the chains in British Columbia. The rocks are old, however, ranging in age from the Cambrian to the Carboniferous. Crystalline rocks are practically absent and many ridges are formed of limestone strata which perhaps underlie the eastern plains and

1) Stieler's Atlas, Karte von Canada, gibt 5900 m an. (Drd.)

are here turned up on their edges and folded. The range is 60 miles (97 km) wide, with an average height of 8000 feet (2450 m). Several peaks reach 10,000 feet (3050 m). Mount Murchison and Mount Hooker are 13,500 feet (4100 m) and Mount Brown is 16,000 feet (4880 m).

West of the Rocky Mountains proper, but physiographically in the above description included with them, and of much earlier geologic age, are three ranges of mountains. These ranges rise from narrow valleys. They are composed of crystalline, granites, schists and gneisses. Commencing at the east, they are denominated — the Purcell, the Selkirk and the Gold ranges. They probably do not rise much above 10,000 feet (3050 m). Mount Sir Donald for example is 10,645 feet (3236 m), Mount MacDonald 9440 feet (2870 m) and Mount Tupper 9030 feet (2745 m), all in the central Selkirk range. The Columbia River flows around the Selkirk range. Flowing from the Columbia lakes, it runs north along the eastern base of the Selkirks, where it bends around the head of the range in a sudden curve and flows in a diametrically opposite direction south between the Selkirk and Gold ranges. These ranges are more rounded than the Rockies, and the upheaval is more confused. The Selkirk range is about 80 miles (29 km) wide and enormous glaciers fill the upper valleys, reminding one of the mountains of Switzerland. West of the Gold range, the interior plateau, 100 miles (161 km) wide, intervenes and is bounded on the west by the Cascade range, an old system consisting of granite, gneiss and schists.

The river systems of British Columbia may be described under two heads. The Fraser River is the chief one, 740 miles (1191 km) long. It reaches out in all directions and accentuates all the peculiar twists and turns of the river systems of the region. It flows at first northwest, then south, until at Hope, it bends abruptly west after a turbulent rapid course through the eastern mountains; when at last, it bursts its way through the Cascade range by the stupendous canons, which bear its name. Secondly, the Columbia River and its chief tributary the Kootenay perform their eccentric evolutions in the south-east corner of the province.

British Columbia in addition to its system of mountains has one of the most remarkable sea coasts in the world, abounding in harbors and bordered by an archipelago of islands. Vancouver Island is the largest of these. It is 285 miles (459 km) long and 40 to 80 miles (64—129 km) wide and possesses a mountain range, which as a backbone, runs its entire length. North of Vancouver Island, the Queen Charlotte Islands are found. The Strait of Juan de Fuca and the Strait of Georgia are inland extensions of the Pacific Ocean of great importance in the future development of the country.

*The Eastern Lakes and St. Lawrence.* The drainage system of the St. Lawrence River also comprises that of the Great lakes and is unique among the river systems of the world. The river and its tributaries are drowned at the mouths, so that the salt water of the ocean enters to form the broad Bay of St. Lawrence with its irregular margin. The water area narrows as one

passes up stream and the water freshens though the tide rises, nearly as far, as Montreal. Above this place, the river becomes a series of rapids separated by quieter stretches of water. A maze of islands, the Thousand Islands, are at the outlet of Lake Ontario, itself one of the five Great Lakes which constitute the system. These lakes are connected by broad rivers and straits interrupted at one place by the greatest fall in the world, that of Niagara. The water area above the outlet of Lake Ontario is 95,275 square miles (245,762 qkm), but to this entire area there is no large tributary river. The divide of the system is generally close to the lakes, so that the entire drainage area is about 270,000 square miles (693,000 qkm).

The beds of all the lakes excepting Erie, are below sea level and even if their water surface were lowered down to sea level, there would still remain large bodies of water. TARR [1]) says: "Whatever view has been prominently held concerning the preglacial history of this region, it has been uniformly agreed that during or immediately after the glacial period, the preglacial valleys have been transformed to basins. While we now know that most of these lakes are the result of irregular drift deposits, Ramsay advocated the view that many were due to ice erosion, and suggested that the Great Lakes themselves were rock basins carved out by ice erosion".

The valley of the St. Lawrence River is bounded on the north in its whole length by the Laurentian highlands. They are but a short distance from the north shore of the river until the Saguenay is reached, when they come out upon it. From thence, the mountains run parallel with the river to within 20 miles (32 km) of the city of Quebec. There at Cape Tourmente, they turn away from the river, but still follow it a distance running west until they strike the Ottawa River the chief tributary of the St. Lawrence, between Montreal and Ottawa City and follow along up its northern bank until they cross the river at Lake des Chats into the province of Ontario. The Laurentian country is full of lakes, the sources of perennial streams which flow down into the central valley in rapids and cascades. The tableland north of the valley is from 1000 to 1600 feet (304—486 m) high, and worn into rounded hills and eminences. Les Eboulements is 2547 feet (774 m) high and north of Montreal. Trembling Mountain 2380 feet is another high point. The central plain of the St. Lawrence extends from Quebec, its gateway, westward, gradually widening to Lake Ontario. A line of completely detached hills cross this level and fertile plain at distances varying from 15 to 25 miles (24—41 km). These hills with but one exception are of igneous rock rising sharply out of the level fields. Mount Royal behind the city of Montreal is one of the most noted of these.

South of the St. Lawrence, the Appalachian chain known in Vermont as the Green Mountains crosses the border and continues north-easterly, as the Notre Dame Mountains, a series of ridges of no great altitude. A few peaks in the range, as Sutton Mountain, reach an elevation of 4000 feet.

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1) TARR, The physical Geography of New York State. 1902: 232.

North of Lake Ontario, which finds its outlet in the St. Lawrence River, is an undulating plain without any prominent elevations to mark its surface and sloping down gradually to Lakes Huron, Erie and Ontario on the south and west and to the Ottawa River on the north. The northern shores of lakes Huron and Superior are high and bold, but the shores of lakes Erie and Ontario are low. The province is drained by numerous streams, such as the Ottawa and the Trent. Lakes abound, large and small. Lake Erie finds its outlet into Lake Ontario through the Niagara River on which is situated Niagara Falls. Detroit River, which enlarges into Lake St. Clair, connects lakes Huron and Erie. Lake Huron is connected with Lake Michigan by the Strait of Mackinaw and with Lake Superior by River St. Mary. Lake Superior, 420 miles (676 km) long and 80 miles (129 km) wide, is the largest sheet of fresh water on the globe, encircled by steep rocky cliffs of Archaean age, interrupted by immense masses of granite and basalt. The water is clear and deep, 900 feet. St. Louis River falls in at the head of the lake. — Few rivers of importance drain into the Great Lakes from the United States, or south side. The Maumee drains from the State of Ohio into Lake Erie, while St. Joseph River and the Grand empty into Lake Michigan on its eastern side.

## 3. Central Division.

### a. Eastern Section and Appalachian System.

The eastern coast of the United States, north of the 35th parallel, is a broken one. That of Maine emphasizes this statement, as it may almost be called a fjord coast, so frequent are the embayments. Massachusetts Bay is formed by the projecting arm of Cape Cod. Narraghansett Bay is a large and deeply indented arm of the ocean projecting into the southern part of New England. Long Island, which encloses the sound of that name, is 120 miles (193 km) in length and extends east and west protecting part of New York Bay, the most important harbor in the United States, from the fury of the Atlantic Ocean. Smaller islands Martha's Vineyard, Nantucket and Block Island lie to the eastward and on the seaward side of Long Island. South of New York Bay, there are two indentations of importance Delaware and Chesapeake bays. This part of the coast is protected by sand islands and sand bars, which enclose shallow bays and extensive salt marshes. This character of coast extends south to the southern extremity of Florida and the sounds formed behind the sand barriers are even more accentuated on the coast of North Carolina, while on the Pacific side of the United States, there is only one important bay, that of San Francisco between Puget Sound and San Diego.

The peninsula of Florida, forming the eastern boundary of the Gulf of Mexico, is in a considerable part of its surface low, consisting of sand, coral rock and rocks of recent geologic age. The Everglades and Lake Ocheechobee are prominent physiographic features of the southern portion of the

Floridan peninsula which on its west coast is lined with extensive mangrove swamps. The Gulf of Mexico is of large dimensions and its coasts are usually low. The region of the Mississippi delta is flat and consists of the material brought down by that stream.

The Piedmont plateaus are west and northwest of the central portion of the Atlantic plain. The rocks which enter into the formation of them are mainly Archaean and are all more or less of metamorphic character. During Cretaceous time, these plateaus which extend southwest from New York Bay stood at sea-level and formed a peneplain. When the land was upheaved finally, the upheaval included the Piedmont region and this kind of disturbance has continued with intermission until the present time. A fall line separated the Piedmont plateaus from the coastal plain. The Susquehanna River, which enters Chesapeake Bay, is well marked by rapids at the fall line near its mouth and swift waters cross the Piedmont area and continue up into the mountain region. The Delaware, James, Roanoke, Yadkin, Savannah and Santee rivers, the latter formed by the junction of the Catawba, Broad and Saluda rivers, drain the Piedmont region and are characterized by rapids, or by more or less swift water, when they cross the fall line. The region is characterized, then, as a rolling country, with the plateau surface crowned by the ancient hills of granite, quarzite, slates and schists and cut into gorges and valleys with meandering channels and flood plains.

The most important fact in the topography of the central portion of North America is the existence of a central comparatively low plain sloping towards the Gulf of Mexico from a watershed in close proximity to the Great Lakes. Eastward of the Mississippi valley is the Appalachian range of mountains and along the ocean the Atlantic coast plain. Westward of this central plain is the Cordilleran mountain system comprising three parallel ranges, named respectively the Rocky Mountains, Sierra Nevada Mountains and Coast range.

The Appalachian ranges belong to an ancient system of uplift. Volcanic materials have not since Mesozoic times invaded this region, which is in sharp contrast to the mountainous Cordilleran region where eruptive dikes and overflows of Tertiary and post-Tertiary age are found. The Appalachian system comprises the entire complex of mountains, valleys and tablelands which extends from northern New England generally southwest to the Gulf of Mexico. One very important break in the system occurs, occupied by the Hudson and Mohawk rivers. A depression of 152 feet (46 m) would be sufficient to permit the ocean to connect with the St. Lawrence valley via Lake Champlain. No other break in the Appalachian system is as complete as this and by this fact we are compelled to recognize that there are essential points of difference between the mountain complex to the northeast in New England and that lying to the south and southwest of the Hudson River valley.

The New England mountain system is most irregular in its topography. Two great elevations are distinguishable, the Green and the White Mountains.

These are separated by the Connecticut River, which drains south into Long Island Sound. In Maine, the White Mountain system has little coherence. Isolated peaks are the rule. Mount Katahdin is the dominating elevation 5215 feet (1590 m), rising abruptly from the surrounding country filled with enumerable ponds and lakes. In New Hampshire, the White Mountains are grouped around various central points, Mt. Moosilauke, 4810 feet (1462 m), Mt. Lafayette, 5290 feet (1602 m) and Mt. Washington, 6290 feet (1918 m).

With the exception of a narrow belt of Mesozoic rocks in the Connecticut valley, and a limited deposit of late Tertiary age on the eastern boundary of Lake Champlain and on the Atlantic Coast, there are, so far as known, no rocks in the New England district more recent than the Palaeozoic. Western Vermont and Massachusetts have rocks of lower Silurian age. Upper Silurian rocks occur in the Connecticut valley, New Hampshire, eastern Massachusetts and a large part of Maine. In northern Maine, traversing the state in a wide belt, rocks of Upper Silurian and Lower Devonian age are found.

The Adirondack Mountains are topographically separated from the rest of the Appalachian ranges and belong to a geologically older system. The rocks are all eruptive, gabbro and granitic in character. Sedimentary beds occur along the edges of this system especially the eastern margin. Mt. Tahawus or (engl.) Mt. Marcy, 5344 feet (1638 m), is the dominating peak of a region noted for its lakes, lying at an elevation of 1500 to 2000 feet (456—608 m).

Beginning with the Catskill mountains, the orographic and geologic peculiarities of the Appalachian system of Mountains begin to be more clear. In Pennsylvania the characteristic features of the range are developed. The first feature is the collection of eastern ridges known as the Blue Ridge. The second is the central valley variously folded and in which the sequence of the sedimentary deposits is discernible, and third, a system of mountains and tablelands to which the name of Alleghany has been given.

The Great Valley is an important feature in both Pennsylvania and Virginia and its drainage is complicated. The streams of the northern Appalachian ranges are not controlled by the mountains. Two rivers rising in the Alleghany plateau far west of the Alleghany front join in the heart of the mountains of Pennsylvania to form the Susquehanna which empties into Chesapeake Bay. The headwaters of the Potomac lie in the plateau west of the Alleghany mountains and its principal tributary, the Shenandoah, is the largest river north of Tennessee, flowing in the direction of the length of the Appalachian valley. New River, which rises in North Carolina, chooses a difficult way to the Ohio River across the Great Valley and the Alleghany plateau.

These features are accentuated in the South, notably in North Carolina, where the Appalachian system is not a unit, but is a complex containing features of nearly equal topographic importance. These are 1. the Blue Ridge, 2. the eastern Monadnocks and Piedmont valleys, 3. the Unaka range, 4. the

central mountain groups and intermontane valley[1]. — The Blue Ridge may be regarded as forming the extreme eastern range of the Appalachian Mountains, carrying the main divide between the Atlantic and Gulf drainage. It reaches the greatest height in the southern states in Grandfather Mountain, with an altitude of 5964 feet (1817 m). The most striking topographic feature of the Blue Ridge is the great difference in slopes on its opposite sides, for it is steep on the eastern and gradual on the western slopes. The eastern Monadnocks[2]) in the south form several groups of mountains along the extreme eastern border of the mountain belt, which have been more or less completely isolated by the erosion of eastward-flowing streams. The Unaka range may be divided into a northern and southern division. The northern division unites in the region of Grandfather Mountain with the Blue Ridge. Compared with the Blue Ridge, the Unaka range reaches a considerably greater average altitude. Not only are these mountains higher, but their slopes are steeper, and their outlines more angular and rugged.

From a commanding position somewhere on the Unaka range, there may be seen stretching to the east and south a confused aggregation of peaks, ridges and domes. The cultivated valleys are generally hidden from view, and except for an occassional clearing and the grassy "balds" on a few of the higher domes, the whole region is covered by a forest mantle. The interior mountains rise to considerable elevations. A large number of summits reach altitudes between 4000 and 5000 feet (1200 and 1520 m) and a few culminate above 6000 feet (1830 m). The Black Mountains contain the highest peaks of the Appalachian Mountains, culminating in Mount Mitchell, 6711 feet (2045 m), 425 feet (129 m) higher than Mount Washington. Between these groups and forming a sort of platform above which they rise are many broad valleys, commonest toward the head of the streams. Only the smaller streams are flowing at the level of these valleys. Down stream toward the northwest, the broad valleys are found to be more and more deeply cut, until they occupy deep narrow gorges.

The history of the Appalachian region, as far as it concerns this book begins with the Cretaceous period. At least two great cycles of erosion are recorded in the southern Appalachians, in which the surface of an old continent was worn down from a considerable altitude nearly to base level. Shortly after the close of the Carboniferous period the entire Appalachian province was finally lifted above sea level, and its subsequent history is recorded in the land forms. Following this uplift was a long period, during which the region was subjected to the physiographic processes constituting gradation. Finally, toward the close of the Cretaceous period, the whole province was reduced to a nearly featureless plain, relieved only by a few groups of hills, where the highest mountains now stand. After the processes of base leveling

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1) Hayes, C. Wills: The Southern Appalachians. National Geographic Magazine I: 319.
2) Monadnocks is a name applied to a peculiar type of rounded hills.

were nearly completed, that is, toward the close of the Cretaceous period, the region was again uplifted, but unequally, so that at the same time its surface was warped. The streams had become sluggish, but the effect of the uplift was to stimulate them to renewed activity, so that they began cutting upon the last-formed peneplain, a process in which they are still engaged.

The drainage streams of this region find their way either eastward to the Atlantic, southward directly to the Gulf, or to the Mississippi and thence to the Gulf. Those which drain westward into the Mississippi River leave the Blue Ridge with its gentle slopes and low gaps and flow northward in deepening channels directly toward the higher and more rugged Unakas, which they cut through in narrow gorges. Emerging upon the Appalachian valley, those south of New River are intercepted by trunk streams, and led off toward the southwest. From New River to Georgia, the trunk stream is the Tennessee, which leaves its southeastward course and at the same time the broad Appalachian Valley by an abrupt bend at Chattanooga traversing the Cumberland Plateau in a narrow gorge much younger than other portion of its valley. Southward from the Georgia line, the trunk stream is the Coosa, which flows directly to the Gulf, and there is evidence, that the divide separating the Tennessee from the Coosa is extremely young and that until comparatively recent times all the waters flowing west from the Blue Ridge found their way directly to the Gulf across the present Tennessee-Coosa divide.

## b. Western Section: Rocky Mountains.

The Cordilleran System comprises the following six regions beginning in the east: 1. the Rocky mountains; 2. the Great ranges; 3. the Northern or Columbian plateau; 4. the Southern or Colorado plateau; 5. the Sierra Nevada and Cascade range; 6. the Pacific Coast range[1]).

The southern or north and south trending division of the Rocky Mountains is extremely well marked in its eastern edge, the ranges rising abruptly from a very gently sloping plateau. Here is a double range of Mountains quite distinctly marked in Colorado which enclose a system of high plateau-like valleys, known as the North, Middle, South and San Luis parks, elevated from 6000 to 10,000 feet. These parks are at the headwaters of the Platte, Colorado, Arkansas and Rio Grande rivers. Long's Peak 14,271 feet (4350 m) and Pike's Peak 14,147 feet (4312 m) are in the Colorado Range proper and are visible from the plains as conspicuous landmarks.

The Sawatch range lies west of the head of the Arkansas River and its dominating peaks exceed 14,000 feet. Mount Harvard 14,375 feet (4380 m) is the highest peak, while the most noted summit to travellers, is the mountain of the Holy Cross 14,176 feet (4320 m) in altitude. The Elk Mountains next succeed on the west of the Sawatch range to be followed by the plateau region, which is characterized by the parks. Directly west of North Park is

1) Encyclopedia Britannica, ninth edition, Article United States XXIII: 796. 1888.

the Uintah range having an east and a west trend, and thus forming a connecting link between the eastern ranges of the Rocky Mountains and the western, or Wahsatch range, which borders the Great Basin on its eastern side. The Rocky Mountains in Montana and Idaho are more irregular than the Park Mountains. An important range is the Bitterroot which forms the main divide between the Missouri River and Columbia river drainage basins. The Coeur d'Alène ranges lie west and northwest of the Bitterroots. The Big Horn Mountains lie to the east and still farther in that direction are the Black Hills, which are separated from the main Rocky Mountain system.

The Great Basin without an outlet to either ocean lies between the Wahsatch Mountains on the east and the Sierra Nevada mountains on the west. It is an area containing great ranges of mountains with broad valleys between them threaded by few streams, as the region is essentially an arid one. Salt lakes abound, usually found in the smaller basins of which the Great Basin consists. Great Salt Lake, which receives part of the drainage of the Wahsatch mountains, is in the east an inland sea of about 2000 square miles (5180 qkm) and strongly saline through the action of the enormous evaporation of this region.

Two valleys in the Great Basin lie below the level of the sea. One of these is called Death Valley and is found in eastern California. It is a desert lying between the Amargosa and Panamint ranges. The second depressed basin is in southern California and is denominated the Colorado Desert from 100—200 feet below the sea. A low water-parting shuts it off from the Gulf of California and the Colorado River. In times of freshet in the latter, the river overflows and forms a shallow lake in this depression, known as Salton Lake. — Two rivers of the Great Basin merit attention. The Humboldt River rises in the Humboldt Range and flows south-westward, to disappear in the Humboldt sink. This river waters a narrow belt in each valley, which it crosses, and this is true of the Sevier River, which after a long sinuous course empties what little water remains in its channel into Sevier Lake.

Great Salt Lake is the remnant of a much larger lake which geologists tell us covered a large part of the area of the Great Basin. The shore-line can be easily traced high up on the mountains that surround the Basin. This former lake has been called Lake Bonneville and it had its outlet northward into Snake River. The Basin ranges extend far down into Mexico, and have a north-and-south direction. The mountains are never high and are often destitute of large trees, and sometimes are mountain deserts. The blocks out of which the ranges are carved are uplifted abruptly, so that the rocks dip gently away to the other side. These ranges have been modified by vulcanism and the volcanic material is often piled up in peaks and small plateaus. The Colorado River of the West naturally divides the region into a northern and a southeastern portion [1]).

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1) Powell, John W.: Physiographic Regions of the United States. National Geographic Monographs Vol. I, No. 3. 1895.

## c. Columbia Plateau.

West of the Rocky Mountains is a great plateau region which is drained by tributaries of the Columbia River. Hence it is called the Columbia Plateau. It is a complex of tablelands of diastrophic and volcanic origin, relieved by a few great mountains and with many beautiful valleys. The region in Cretaceous time had extensive plains, broad valleys high mountains and some portions were under the sea. Granite, quarzite, and mica-schist were the rocks with those of later age on their flanks. Extensive diastropism occurred in the Eocene and with it volcanic activity by which mountain cones were erected. Later than this in geologic time (Neocene), the more fluid lavas broke out in many new places forming thin coulees and frequently filling, or obstructing valleys. These eruptions continued for a long period, until the old topography was completely changed. Lakes were formed by the damming of valleys and some of the best agricultural land occurs where these lakes were subsequently drained. The streams of the region have cut narrow canons. Snake River runs for several hundreds of miles through a canon carved in the lavas and is the most important stream of this district. The walls of the gorge are often precipitous and late lava coulees, stretching across the river bed, are the cause of waterfalls of which Shoshone Falls is the most notable example. The region of the Columbia Plateau comprises large portions of the present states of Washington, Oregon and Idaho with a small extension into the northern edge of Nevada and Utah.

## d. Colorado Plateau.

The Colorado Plateau, or system of plateaus was covered by a shallow sea during the Cretaceous period. This great extension of the ocean stretched far to the east, northeast and southeast nearly to a line drawn east of the present Mississippi River. The Park Mountains formed an archipelago of islands during this time. At the close of the Cretaceous and in the early Eocene periods, the sea water gradually retreated by an irregular upheaval. The drainage waters were impounded by this upheaval and great basins were formed which became great inland lakes. The slow upheaval continued through Eocene time with frequent vulcanism. Great plateaus were also formed to be subsequently modified and dissected by the rains and the streams. The rocks forming beneath the sea were in a horizontal position and when the upheaval occurred, they became dry land and were inclined at an angle to their former position. As the elevation of the region continued, all the lakes were drained by the cutting of outlet channels and the whole region became arid. In late Neocene time, when the lakes were drained, their bottoms became valleys which were occupied by streams running into the Colorado and the Rio Grande del Norte. Thus, this plateau region is dissected by a vast network of streams. The streams usually have deep channels. Rills born of showers have often cut deep but larger gorges and the rivers have cut mighty canyons.

Thus with cliffs, terraced and buttressed, with towers, pinnacles, minarets and cut with deep reentering angles, the entire region is one of picturesque grandeur.

While every stream in this region flows in a canyon, the most remarkable succession of canyons is that on the main stream of this region, the Colorado, and its principal branch, the Green. The Green River, on leaving the Wind River Mountains traverses southward a great plain, or valley, known as the Green river basin and meets the Uinta range at right angles to its course. This range it cuts through in gorges of enormous depth and enters the Uinta basin, crossing it to enter a canyon in the sedimentory rocks. Passing through three such canyons, the Green River joins its forces with the Colorado River in the gloomy depths of the Stillwater Canyon. The Colorado River buries itself deeper and deeper until at the mouth of the Colorado Chiquito, it is 3800 feet (1158 m) below the surface. This is Marble Canyon, and the river turns to the west to enter the gorge known as the Grand Canyon, where the canyon is at its maximum depth 7000 feet (2134 m). To the north of the Colorado Plateau is a plateau known as the Uinta Mountains having its greatest length in an east-and-west direction. Others lie to the southeast, such as Santa Fe, San Francisco and Pecos plateaus.

## e. Pacific Mountains.

West of the Great Basin are found the Sierra Nevada Mountains, which extend along the eastern border of the State of California from Tejon Pass northward to Lassen Peak, a distance of 450 miles (724 km). South of Tejon Pass, the height of these mountains decreases and they become topographically identified with the Coast Range. North of Lassen Peak, the metamorphic rocks which make up the Sierras disappear beneath a volcanic plateau with Mount Shasta at its southern base. The average breadth of the Sierra Nevada Mountains is 80 miles (129 km). The highest peaks are the following:

| | | | |
|---|---|---|---|
| Mount Whitney . . . | 14,898 | feet | (4530 m; 4410 m eailier maps). |
| » Shasta . . . . | 14,380 | » | (4382 m). |
| » Corcoran . . . | 14,093 | » | (4296 m). |
| Kaweah Peak . . . . | 14,000 | » | (4267 m). |
| Mount Lyell . . . . . | 13,042 | » | (3984 m). |
| » Dana . . . . . | 12,992 | » | (3960 m). |
| Castle Peak . . . . . | 12,500 | » | (3950 m). |
| Mount Shastina . . . | 12,433 | » | (3800 m). |
| Clark Peak. . . . . . | 11,295 | » | (3443 m). |
| Stanislaus Peak . . . | 11,202 | » | (3415 m). |
| Mono Pass . . . . . . | 10,765 | » | (3280 m). |
| Lassen Peak . . . . . | 10,437 | » | (3181 m). |
| Arnot Peak . . . . . | 10,036 | » | (3058 m). |

The Yosemite Valley is a feature of the Sierra Nevada range which merits a passing mention. The valley is a nearly level area, 6 miles in length and from half a mile to a mile in width. It is a gigantic trough with precipitous, almost vertical walls, which are noted for their great height compared

with the width of the valley itself. Very little talus has accumulated at the foot of these cliffs, which further accentuates their height. The objects which arrest the attention are the great granite cliffs and crags rising, 3000 to 4000 feet above the floor of the valley and the grand and beautiful waterfalls by which the many tributaries of the Merced River join that river in the level below by falling over the cliffs from great heights. Chief of these is the Yosemite Fall, (2462 feet), the Bridal Veil Fall (630 feet), while the Vernal Fall 350 feet and the Nevada Fall 600 feet in height are of scarcely less importance.

Small residual glaciers abound in the high Sierras[1]. Muir found sixty-five in that portion of the range lying between latitude 36° 30° and 39°. The largest of these glaciers on Mount Shasta descends to within 9500 feet of the level of the sea, which is perhaps the lowest point reached by any glacier within the bounds of California, the average height of all being not far from 11,000 feet (3350 m). Traces of the vanished glaciers abound on the Sierra, as far south, as latitude 36°. The polished rock surfaces, the most evanescent of glacial records, are still found in a perfect state of preservation on the upper half of the middle portion of the range.

Glacial lakes also abound in this region. All the upper branches of the rivers are provided with lakes. They lie embosomed in deep woods, in the bottoms of canons, high on bald table-lands and around the base of icy peaks. The whole number in the Sierra can hardly be less than fifteen hundred and two thirds, or more of these, lie on the western flank of the range. Lake Tahoe 22 miles (35 km) long by about 10 wide and from 500 to over 1600 feet in depth, is the largest of all the sierra lakes. It lies just beyond the northern limit of the higher portion of the range between the main axis and a spur that puts out on the east side from near the head of the Carson River. Donner Lake, three miles long lies about ten miles to the north of Tahoe, and a few miles farther north lies Lake Independence about the same size as Donner. Muir states: "In the basin of the Merced River I counted 131, of which 111 are upon the tributaries that fall so grandly into Yosemite Valley. Pohono Creek, which forms the fall of that name, takes its rise in a beautiful lake, lying beneath the shadow of a lofty granite spur that puts out from Buena Vista Peak. This is now the only lake left in the whole Pohono basin. The Illilouette has sixteen, the Nevada no fewer than sixty-seven, and Tenaya eight, Hoffmann Creek five and Yosemite Creek fourteen. There are but two other lake-bearing affluents of the Merced, viz., the South Fork with fifteen, and Cascade Creek with five, both of which unite with the main trunk below Yosemite."

Upon the filling up of these lakes either by the action of vegetation, or the deposit of eroded material, glacier meadows are formed. These are smooth, level, silky lawns, lying imbedded in the upper forests, on the floors of the

1) MUIR, JOHN: The mountains of California, p. 20. 1901.

valleys, and along the backs of the main dividing ridges, at a height of about 8000 to 9500 feet (2440—2900 m) above the sea. Besides these lake meadows several other forms may be distinguished, viz., hanging meadows, found lying asland upon moraine-covered hillsides; bogmeadows formed by the damming of some perennial stream and small pot-hole meadows found along the banks of the main streams, on the summits of rocky ridges or on glacier pavements.

North of Lassen Peak, an isolated volcanic cone, 10,437 feet in height, the range is broken through transversely by a great fault, or great depression comparatively level. Seventy miles north-west of Lassen Peak rises Mount Shasta, 14,380 feet (4382 m), standing in remarkable isolation on a base between 10,000 and 11,000 feet. North of Mount Shasta the mountain mass becomes the Cascade range. The ridge is comparatively low and on it at irregular intervals rise great volcanic cones. Mount Pitt, 9760 feet (2975 m), is a well-defined cone. Mount Jefferson is of a similar character and between Pitt and Jefferson occur five sharp peaks known as the known as the Three Sisters. All through this portion of the range are evidences of recent volcanic activity in the form of craters and outflows of lavas. The Columbia River breaks through the Cascade range 100 miles (161 km) north of Mount Jefferson, where the volcanic masses have been cut through at the Dalles, which are great, broad flat sheets of lava. Near this point rise three well-defined volcanic cones: Mount Adams 12,470 feet (3799 m), Mount St. Helens 10,000 feet (3048 m) and Mount Hood, 11,225 feet (3421 m). Mount Rainier 14,526 feet (4400 m) lies apart from these snowcapped peaks 75 miles over against Puget Sound, while north of Rainier, or Mount Tacoma, is Mount Baker, 10,827 feet.

The Coast ranges of California and Oregon are west of the Sierra Nevada and the Cascade range. The Coast ranges are newer geologically and of less elevation. The upheaval of the Sierra Nevada Mountains took place according to Whitney at the close of the Jurassic epoch, whereas, that of the Coast ranges was the result of agencies operating during the latter part of the Tertiary and continuing down to the post-Pliocene. The portion south of San Francisco Bay is Miocene. These coast ranges are severed, where the San Joaquin River from the San Joaquin valley joins the Sacramento River from the valley of the same name and flows through the Golden Gate into the ocean. In the vicinity of San Francisco Bay, their altitude ranges from a few hundred to 3000 or 4000 feet. Prominent points near that bay are Mount Diablo, 3849 feet, Mount Hamilton, 4209 feet, and Mount Helena, 4343 feet. Mount Bally 150 miles (241 km) north of San Francisco has an elevation of 6246 feet. Finally near the southern end of this chain of mountains are found the San Bernardino and San Jacinto Mountains, each rising to about 11,000 feet (3350 m). Here this range joins the Sierra Nevada Mountains, which make a turn to the west, while in the southern part of Oregon and in northern California, they become confused with the Cascade Range.

## f. The Great Valley.

The Great Valley between the Appalachian and the Cordilleran mountain systems is mainly drained southward to the Gulf of Mexico by the Mississippi River and its tributaries the Minnesota, Des Moines, Missouri (and its affluents), Arkansas and Red river, flowing from the west, besides the Illinois, the Ohio (and its branches the Wabash, Cumberland and Tennessee rivers) and Yazoo rivers emptying into it from the east. This valley is a great level plain, except where scored by streams. In the east, small prairies existed, while beyond the Mississippi, the prairies were interrupted only by the groves that border the streams. This great prairie sweeps around the Ozark hills in Missouri, Arkansas and Oklahoma and extends southward to the Rio Grande del Norte. The great ice sheet covered this prairie down to the mouth of the Ohio River, and wherever it was spread, beds of clay, sand, gravel and glacial hills are found. The prairies merge imperceptibly on the west into the region known as the "Great Plains", but which are really topographically speaking great plateaus. Below the Ohio River on either side of the Mississippi River, occur the Gulf plains named by Powell, the east Gulf plain, the west Gulf plain, the flood plain of the Mississippi and coastal marshes and the submerged plain, extending into the Gulf. The most interesting of these is the Mississippi flood plain, which starts at the foot of the great glacial deposits in Illinois and at the Gulf end expands into a great delta built by sediments brought down by that great river. The outlines of this flood plain are marked by high bluffs of loess. This great plain seems to have been somewhat more depressed during glacial time, than at present, and the water from the glacier gathered into a great basin which emptied into the Gulf.

The Ozark Mountains extend southward and westward from the Iron Mountains of Missouri. The region north of the Arkansas River has been a great plateau, but it is now deeply trenched by numerous winding streams. The rocks of this region in the southern district bend in a synclinal fold and are eroded into long parallel mountain ridges with intervening valleys. The streams in the most southern portion of the region are transverse to the rock structure.

The Great Plains, or plateau region, extends from British America to the Rio Grande River. The Missouri district is deeply cut by the Missouri River and its tributaries. The Platte plateau is drained by rivers that flow in a general easterly direction into the Mississippi River, while the Arkansas plateau is drained by the Arkansas, the Cimarron and two of the Canadian rivers. The Pecos tableland in Texas is drained by the Pecos and the tributaries of the Red, Brazos, Neuces and Colorado rivers, and is known also as, the Llano Estacado, or Staked Plain.

## 4. Southern Division.

### a. Mexico.

Mexico lies between 14° 30′42″ and 32° 41′ north latitude and 86° 46′ 8″ and 117° 7′ 31″ longitude west from Greenwich. It is approximately in the form of an inverted cornucopia with the waters of the Gulf of Mexico on the east and those of the Pacific Ocean on the west. Its greatest length is about 1900 miles (3157 km), and its greatest width 750 miles (1204 km), and its least width at the Isthmus of Tehuantepec about 100 miles (161 km).

Mexico is clearly divided by the low-lying Tehuantepec Isthmus into two distinct geographic regions. The section to the south belongs partly to the Central American mountain system partly to the limestone plateau formation of Yucatan. The section north of the Tehuantepec is a plateau flanked on the east and west by two great mountain chains. Rising rapidly by a succession of terraces from the low sandy coasts on the east and west, it culminates in this central plateau, running in a northwesterly and southeasterly direction, and having an elevation ranging from 4000 to 8000 feet (1200—2400 m) above the sea. High above this plateau, which was raised in Cretaceous times and has stood undisturbed by depression since then, tower the snow-capped summits of several volcanoes, as Popocatepetl: 17,540 (17,500, 17,748) feet (5450 m), Orizaba or Citlaltepetl: 18,250 (17,362, 17,373) feet (5580 m), Ixtaccihuatl: 16,076 (16,900) feet, Toluca: 15,091 (14,950) feet, Colima (Nevado de): 14,363 (14,100, 14,120) feet (4378 m), Volcan de Colima: 12,750 feet, and Ajusco: 13,628 feet.

Two mountain ranges traverse Mexico, the Sierra Madre Oriental, parallelling the Gulf coast and Sierra Madre Occidental, the Pacific coast. The eastern range runs from 10 to 100 miles (16—160 km) from the coast and its eastern slopes are terraced from the Gulf to the level of the tableland above. In the Nuevo Leon and Tamaulipas sections, it is scarcely more than 6000 feet high and several passes are less than 5000 feet. "North of the Cofre de Perote Volcano in Vera Cruz, the eastern Sierra Madre skirts the shores of the Gulf of Mexico without any break, as far, as the Rio Panuco on the frontier of the State of Tamaulipas. In this section it slopes somewhat gently seawards, and much more abruptly westward down to the Anahuac plateau. Beyond the Panuco the main range having thrown off several spurs and ridges towards the central plains, begins to diverge gradually from the coast-line taking a normal north-westerly trend along the eastern edge of the plateau for the rest of its course to the Rio Grande"[1]).

The western Sierra Madre mountains approach much nearer the coast. They are loftier and more continuous and maintain with little interruption a

1) KEANE, A. H.: Central and South America, Vol. II Stanford's Compendium of Geography and Travel, new issue 1901. p. 42.

mean altitude of from 10,000 to 12,000 feet (3050—3660 m) for two thousand miles from Oaxaca far into Arizona. This range has several branches running in different directions, the most continuous being the Sierra Madre of the Pacific with which runs parallel the Sierra de la Giganta in Lower California which has a mean height of about 4000 feet (1220 m).

Between these two ranges and the central Cordillera to the south is the great Mexican tableland, next to those of Tibet and Bolivia, the loftiest and most extensive on the globe. From the lacustrine Valley of Mexico, it stretches at a nearly uniform elevation of 7500 feet (2300 m) to the Rio Grande del Norte. In a total distance of 1225 miles (1971 km), the absolute incline is only 3632 feet (1107 m), from 7350 (2240 m) at the capital to 3718 (1133 m) at El Paso. With this may be compared the drop of 7350 from the City of Mexico to Vera Cruz at sealevel, a distance of about 264 miles (425 km). Barrancas, or deep canyons, however, break the uniformity of the tableland. The most remarkable of these is the Barranca de Mochititle between Guadalajara and Tepic and that of Beltran between Guadalajara and Colima.

The central Cordilleran mountains form cross ridges which culminate in Popocatepetl and Ixtaccihuatl. The volcanoes and Orizaba, Jorullo, Colima, however, belong to a more recent upheaval, as they are nearly at right angles to the main axis of the central plateau. Nearly parallel to these are the sierras of Guerrero and those of Oaxaca and Chiapas toward the frontier of Guatemala.

The eastern coast of Mexico, bathed by the Caribbean Sea and the Gulf of Mexico is flat, low and sandy except near the mouth of the Tabasco River, where at some distance from the coast appear the heights of San Gabriel. The coast on the Pacific side, through generally low, is here and there broken by spurs extending from the cordilleras to the ocean. Few bays worthy of note are found on these coasts, which lack prominent indentations.

The largest lake in Mexico is Lake Chapala measuring over 80 miles in length by 30 in breadth. The Valley of Mexico has seven lakes, one fresh and six salt water, the three largest being Chalco, Xochimilco and Texcoco. The other lakes worthy of mention are Catemaco in the State of Vera Cruz, Cariel and Carpintero in the State of Tamaulipas; Encantado, in Tabasco; Bacalor, in Yucatan; Alcuzague, in Colima; Cuitzeo and Patzcuaro, in Michoacan; Yuriria, in Guanajuato, and Meztitlan in Hidalgo.

A large number of islands lie off the Mexico coasts. Among the most prominent are Carmen, the largest in the Gulf of Mexico; Guadalupe, about 75 miles (121 km) from the west coast of Lower California, Tres Marias, a group of the same coast; the Revillagigedo group near the Colima coast and Alcatraz Island not far from the coast of the State of Michoacan.

The principal rivers of Mexico are the Rio Grande, 1500 miles (2414 km) long forming, from El Paso, Texas to the Sea, the boundary line between the United States and Mexico; the Lerma, or Santiago, 540 miles (869 km) long; the Mescala or Balsas, 426 miles (685 km) in length; the Yaqui, 390 miles

(628 km); the Grijalva, 350 miles; the Fuerte, 340 miles (547 km); the Usumacinta 330 miles (531 km) and several others. The topographic conditions of the country are such as to cause these streams, in their progress toward the sea, to be continually precipitated in the form of cascades[1]).

The isthmus of Tehuantepec is narrow and low averaging little over 400 feet (128 m) above sea level, and rising to scarcely 3000 feet (914 m) even in the ridge which, on the Pacific side, forms a sort of connecting link between North and Central America. From this ridge the country clopes northward to the Gulf of Mexico through a series of terraced cretaceous formations, which were deposited when a sound connected the Atlantic and Pacific Oceans in Mesozoic time. Later when the marine deposits had been upraised the chalk cliffs became overlaid in several places by Tertiary material. East Mexico which comprises the four states of Chiapas, Tabasco, Campeche and Yucatan consists of two distinct physiographic division, viz., the Central American orographic system (Chiapas, Tabasco) and the marine limestone division of Campeche and Yucatan. Chiapas has its Sierra Madre on the Pacific coast, which forms a northern continuation of the Guatemalan system. With an average altitude of 5000 feet (1524 m), two volcanic peaks Tacana and Xoconochco rise respectively 11,500 (13,300) feet (3505 m) and 7900 feet (2408 m). East of the Sierra Madre is an undulating plain, well watered and wooded. — Yucatan possesses no mountains except a ridge 400 to 500 feet (120—150 m) high. The country is a tableland of blunt peninsular shape consisting of limestone rocks, which abound in caverns of which Loltun perhaps is the most famous. The Great Bank of Yucatan is a submarine extension of the peninsula and is being constantly added to by the activity of coral.

In the Peninsula of California, the central Sierra de la Giganta forms a series culmininating in a peak about 8000 feet high, consisting of a granite mass which shows signs of glacial action in the form of moraines, especially on the side facing the Gulf. Here the ranges are separated by the San Jose del Cabo valley from a non-fossiliferous limestone ridge, beyond which volcanic stratified red rocks prevail on the shores of the Gulf of California.

"The Geology of Mexico has been but imperfectly studied. In the higher ranges the prevailing formations are granite, which seem also to form the foundations of the plateaus, above which rise the traps, basalts, mineral-bearing porphyries, and more recent lavas. Hence LYELL's theory that Mexico consisted originally of granite ranges with intervening valleys subsequently filled up to the level of the plateaus by subterranean eruptions. Igneous rocks of every geologic epoch certainly form to a large extent the superstructure of the central plateau. But the Mexican table-land seems to consist mainly of metamorphic formations which have been partly upheaved, partly interpenetrated and overlaid by igneous masses of all epochs and which are chiefly represented

1) **Bureau of American Republics: Mexico, a geographical Sketch. Washington 1900, p. 8.**

by shales, greywacke, greenstones, silicious schists and especially unfossiliferous limestones"[1]). HEILPRIN believes that "much of this plateau has been formed by a progressive and long continued accumulation of detrital material, representing in part the distribution products resulting from mountain destruction and in greater part the discharges from an almost endless number of volcanic openings. These have, as it were, filled the original valleys to their tips, and it is thus upon the new surface that the more recent existing valleys have been imposed".

The history of Mexico in pre-Cretaceous times is very obscure. Probably it was covered by sea, as is also assumed by Neumayr, in the Jurassic, at least in part (Hill 1898). But it seems to be well established that in the lower Cretaceous (Hill 1893) almost all of Mexico was submerged from the Atlantic to the Pacific side. In the middle of the Cretaceous period a large part of Mexico became land forming a southern prolongation of the western part of North America, which was separated in the upper Cretaceous from the eastern. The mountains raised in Cretaceous times have not been disturbed by depression, but the valleys have been filled up with detritus from them and filled in by volcanic action, so that a plateau has been formed which has been only slightly eroded because of arid conditions and because it consists of valleys which have no outlets, but collect in their depressions the material eroded from all sides.

The highest ranges are formed mainly of plutonic and volcanic rocks, such as granites, syenites, diorites, mineral-bearing trachytes, basalts, porphyries, obsidian, pearlstone, sulphur, pumice, lavas, tufa and other recent volcanic discharges. The most valuable rocks are the argentiferous porphyries and schists of the central plateau and of Sinaloa. Horizontal and stratified rocks, of extremely limited extent in the south, are largely developed in the northern states and chalk becomes very prevalent toward the Rio Grande and Rio Gila valleys. The sandy desert tracts, which cover north Mexico, probably owe their physiographic character to this chalk and sandstone. Thus the Bolson de Mapimi, a vast rocky wilderness, occupies and area perhaps 50,000 square miles in Coahuila and parts of other states.

## b. Central America.

The Central American states are Guatemala, Honduras, Belize, San Salvador, Nicaragua, Costa Rica and Panama. A large part of Central America may be said to be mountainous. The main, or central chain, the Cordilleras, run along the Pacific coast in a general northwest-southeast direction through Guatemala, San Salvador, Honduras, Nicaragua, Costa Rica and Panama. In Guatemala, the range keeps on the whole parallel with the Pacific coast, at a distance of 40 or 45 miles. Its mean elevation is about 7000 feet, (Peak of Tajomulco 13,800 feet [4210 m]). Forming the main watershed between the

1) ROMERO, MATIAS: Coffee and India-rubber Culture in Mexico. New York 1898. p. 12.

Pacific and Atlantic coast drainage-systems, it is pierced here and there with rivers. It enters the Mexican state of Chiapas as the mountains of Istatan. The Sierra de Chama strikes eastward from the Sierra Madre towards Belize where it is denominated the Cookscomb, and one or two other mountain chains follow the same general course. The general relief of the country is of the most varied description, the mountains descending in all kinds of terraces. No true plateaus are found. The number of volcanic summits, according to Bernouilli is 14 or 15, while Foledo makes the number no less than 31. Volcan de Fuego is perhaps the most important 12,821 (12,655, 12,578) feet (3835 m), while Volcan de Agua 13,108 (12,311) feet (3995 m) is famous for the fact, that it destroyed the city of Old Guatemala by a deluge of water.

*The single states.* Guatemala has many streams and rivers. The streams which drain the Pacific coast are small and rapid, while the eastern drainage plain is supplied with a number of good sized rivers. The Motagua, 250 miles (400 km) long, forms a delta on the south of the Gulf of Honduras. The Polochic is about 180 miles (290 km) in length, while the Guadalupe, the Rio de la Pasion and Chisoy unite to form the Usumacinta, which, passing through Mexican territory, empties into the Bay of Campeachy. Lake Peten is an irregular basin about 27 miles long with an extreme breadth of 13 miles. Lake Izabal is the head of the Polochic River and Lake Atitlan is a land-locked basin in the mountains at an elevation of 5300 feet (1615 m). Thus in Guatemala, three orographic regions are distinguishable: 1. A northern district which is relatively low comprising the larger part of the department of Peten. 2. A central district composed of mountain ranges, running generally east to west and divided into chains of Cretaceous and Tertiary formations in the north, and chains of Paleozoic and Archaic formations. 3. A southern district formed chiefly of eruptive mountain chains which culminate in volcanoes, such as Tacana, Fuego and Agua.

The main chain of mountains in Honduras does not approach the Pacific coast closer than 50 or 60 miles. It makes several turns on itself, thus enclosing valleys, or interior basins. These mountains may be said to form a continuation of those in Guatemala. The Omoa range with its culminating peak, 10,000 (Bates 8,000) feet towers above Amatique Bay, while the Congrehoy and Poyas ranges are near the Atlantic coast their crests rising 6000 to 8000 feet. The ranges run in the same general direction as in Guatemala, but they are interrupted by a great transverse plain, the plain of Comayagua having an extreme length of about 40 miles. From this valley extending due north to the Atlantic Ocean is found the valley of the Humuya River and due south to the Pacific Ocean, the Goascoran River Valley which thus completes a depression which extends from the Atlantic to the Pacific oceans and at one time formed a marine channel connecting the two oceans. The rivers of this region are numerous. The Ulua River is the largest, draining nearly one-third of Honduras. It discharges a larger amount of water into the sea than any other Central American river. Rio Tinto is a considerable stream,

while the Rio Segovia is the longest rising withing 50 miles of the Bay of Fonseca and flowing into the Caribbean Sea at Cape Gracias à Dios.

San Salvador with the exception of a comparatively low alluvial coast plain, is a plateau 2000 feet in elevation diversified by a large number of volcanic cones more recent than the Cordilleras themselves. The Rio Lempa rises in Honduras, crosses a corner of Honduras, enters San Salvador and draining Laguna de Guija, it flows through a magnificient valley and reaches the Pacific.

The low swampy Mosquito Coast of Nicaragua is broken by two lagoons and is fringed by cays and reefs. Parallel with the shore extends an almost continuous fringe of coral reefs and islands. The reefs are continually closing up the gaps by which they are broken, so that a new coast line will be formed when the lagoon behind is filled in. The coast in the past has been formed by the seaward growth of the land, by the combined action of coral polyps, and deposits of sediment washed down by the streams. Impenetrable mangrove swamps are found, which further contribute to this upbuilding and the water is deep close to the shore. The great geographic feature is the depression at a mean elevation of scarcely 100 feet above the sea occupied by two great lakes Nicaragua and Managua into which the drainage of the western provinces discharges and through the Rio San Juan to the Atlantic. This river pierces the main chain of the Cordilleras de los Andes composed of andesites, trachytes, greenstone and metalliferous porphyries which sweeps around the lake basin at a mean elevation of 4000 to 5000 feet (1279—1524 m). Two-thirds of Nicaragua is occupied by the terrace-lands of the north. Towards the low plains of the lakes, they end abruptly, and their escarped face appears as a great mountain wall with deep valleys cut through it. Towards the north, they merge gradually with the mountains and plateaus of Honduras. Towards the east, they slope down to the Atlantic coast, with a number of spurs lying between the rivers. Llanos, such as Jinotega, Esteli and Ocotal, have an average height of 3000 feet. The lacustrine depression is traversed throughout its entire length by a series of isolated volcanic cones. North of the lakes the chain takes the name of Maribios comprising Coseguina (3835, 2777 feet), El Viejo, 6000 (6266, 5839) feet, Santa Clara (4506), Telica (3409), Axusco and Momotombo 7000 (6121, 4128) feet and Corongo 9908 feet. Two twin peaks in Lake Nicaragua are named respectively Ometepec, 4100 feet, and Madera, 4190 feet. Barren lava fields (malpais) extend for miles in that portion of Nicaragua between the lakes and the Pacific Ocean, where the Coast Range comprising the mountains of Managua, Granada and Rivas seldom rising above 2000 feet, merges northwards in the plains of Conejo and Leon and forms a continuation of the system in Salvador and Costa Rica. The Pacific coast of Nicaragua has no rivers of any size, while Lake Nicaragua, 110 miles long and 40 broad, is drained by the Rio San Juan, 128 miles (206 km) long. Several unnavigable streams in the little known region of rugged plateaus and savannas between the lacustrine depression and the Mosquito coast drain eastward to the Atlantic.

The Atlantic coast land of Costa Rica is generally low and is characterized by lagoons which have been formed by the action of currents opposite the river mouths. The Pacific coast rises higher. The interior of the country is diversified by mountains, plateaus and valleys. A great volcanic range extends from north-west to south-east from between Lake Nicaragua and the Pacific Ocean to the center of Costa Rica, separating a narrow Pacific slope from the broader descent to the Atlantic. The summits of this range are the peaks of Orosi, 5200 (6000, 5055) feet; Rincon de la Vieja, Miravalles, Poas, 8845 (8895) feet; Barba, 9335 feet (2845 m); Irazu, 10,850 feet (11,000, 11,200 feet) (3414 m); and Turrialba, 10,330 (10,900, 11,350) feet. — The form of the southern half of Costa Rica is determined by the great range called Montaña Dota, 7000 to 9000 feet in elevation, which extends from west to east nearly across the country and from which two branches extend south-eastwards, the one close along the Pacific coast, the other through the center of the country rising in the Cerro Chiriqui 11,850 (10,150, 11,970) feet and Pico Blanco, 11,740 (9650) feet above the sea. — These mountains, as far, as they have been examined, are found to be of eruptive origin, basalts and trachytes predominate, but extensive sedimentary rock formations are also found upon their slopes, as well as vast deposits of boulders earth and volcanic material. — The broad tablelands of San Jose and Cartago, elevated 3000 to 4000 feet, are between the northern and southern masses of these ranges and this central plateau is the most important and as yet the only cultivated region of Costa Rica. The Atlantic Slope is drained by the Rio Frio, San Carlos and Colorado tributaries of the Rio San Juan and in addition by the rivers Reventazon, Chirripo and Chiriqui. The chief streams on the Pacific side are the Tempisque, Rio Grande, Waranjo and Rio Grande de Terraba.

It is clear that the Caribbean Sea once joined the Pacific Ocean through the Valley of the Reventazon River and that in Mesozoic times the high lands of Costa Rica once formed part of a vast archipelago extending from Panama to Tehuantepec, the islands of which possessed volcanic cones, which by their activity filled up and connected the islands to form a mainland. Prof. William M. Gabb in his geologic sketch of the Talamanca Mountains says that the nucleus of the great Cordillera of the interior is formed by the granites and syenites, which, like the sediment that covers them, are broken through here and there by dikes of volcanic origin identical with the eruptive material found on a greater scale in the northern part of Costa Rica. Along the Talamanca coast, calcareous deposits are found in horizontal layers and are probably elevated coralreefs, a rock wich Professor Gabb calls "antillite" and which is developed in the entire Caribbean region. It belongs to the post-Pliocene formation, the last of the Tertiary series. The Costa Rican orographic system passes into Panama through the Cordillera de Chiriqui which traverses the entire isthmus. Low passes break this cordilleran system into a number of loosely connected spurs and ridges. It seems certain that here the two oceans were formerly connected through a number of channels and that Panama like

other parts of Central America constituted a chain of Islands which have since been united by volcanic and meteoric agencies into a continuous landmass separating the oceans. The Central American igneous system is continued in the Panamaian highlands by the Cordillera de Chiriqui (11,850 feet), Rovalo 7020 feet (2140 m), and Cordillera de Veragua. At Culebra Pass, 290 feet, the isthmus contracts to a width of about 34 miles and here the United States government is digging the isthmian canal. Several of the streams in Panama have a somewhat lenghty course in descending from the central uplands. Their basins are narrow and the volume of the streams is not great except during heavy rains, when they become swift and turbulent. Such is the Rio Chagres which flows through the canal strip and empties into the Atlantic near Colon, where its mouth is obstructed by a bar. Rio Bayano on the Pacific coast presents fewer obstacles to the engineers of the canal, because the western slopes of the country are drier.

*General remarks.* — Central America and the West Indies including the Gulf of Mexico and the Caribbean Sea are largely individual in their aspects, although more nearly related to one another and to the northern coast of South America, than they are to the main bodies of the larger continents.

The trends of the great North and South American mountain systems, the Rocky and Andean, if protracted would not connect with each other, but would pass nearly two thousand miles apart. The Andean trends would pass through Jamaica and eastern Cuba and continue in the direction of Nova Scotia. A similar extension of the Rocky Mountains would carry them into the Pacific far west of the South American continent. Between these two great systems of uplift occurs a third to which the name of Antillean may be applied. "East-and-west mountain ranges of the Antillean type occur through the great Antilles, along the Venezuelan and Columbian coast of South America, south of the Orinoco; in the Isthmus of Panama, Costa Rica, and the eastern parts of Nicaragua, Guatemala, Honduras, Chiapas and southern Oaxaca. The two elongated submarine ridges, separated by the deep oceanic valley known as "Bartlett Deep", which stretch across the Caribbean from the Antilles to the Central American coast, from the west end of the Sierra Maestra range of Cuba to the coast of Honduras, and from Jamaica to Cape Gracias à Dios respectively are similar in configuration to the east-and-west mountain ranges of the Greater Antilles, and are, no doubt, genetically a part of them[1]). The mountains and submarine banks described above form thus a perimeter to the depressed Caribbean basin, which sank to great depths when the mountains were elevated.

Central America, the West Indies and the northern margin of South America formed in the Mesozoic period (certainly during Jurassic and Cretaceous) a continental mass (Antillean continent), which was bounded by sea to the north

1) HILL, ROBERT T.: Cuba and Porto Rico with the other Islands of the West Indies. p. 4. 1898.

and south[1]. This continent broke up at the end of the Cretaceous, the chief factor in its destruction being the formation of the Caribbean Sea, which connected with the Pacific Ocean during the lower Tertiary period across the submerged Isthmus of Panama. (See the geologic survey-maps in Part III, chapter I, Fig. 1—4.) The northern remnant of this continent, consisting of the Greater Antilles and parts of present Central America, probably remained a unit up to the Eocene for during the Eocene elevation, there was probably a landway from Cuba across the Bahama banks to the Floridan area, as evidenced by the fact that certain groups of Antillean land mollusks crossed that bridge. But at the end of the Eocene and during Oligocene and Miocene, the connection between the Greater Antilles and the mainland was severed. But it was reestablished toward the end of the Tertiary for before the close of the Tertiary period, the West Indian lands were much more extensive than now, and the Greater Antilles were once continuous. Geologists have proved that during this time the Gulf Stream flowed out of the American Mediterranean as now, but through a passage across the northern half of Florida, so that at one time southern Florida was West Indian. Furthermore, the great banks of the western Caribbean Sea were at that time projections of land probably connecting Central America with Jamaica and possibly Cuba, and in the Miocene a land connection was established between North and South America by the elevation of the Isthmus of Panama, which was previously in existence and connected with the Cordilleran part of the northern continent when the West Indian islands during the upper Cretaceous period were in great part beneath the sea.

## 5. West Indies in general.

The geologic history of the West Indian islands has been marked by remarkable up and down oscillations, so that the land and water areas have undergone marked changes in their relative positions. During the end of the Cretaceous and the beginning of the Tertiary period, when the great Cordilleras of North and South America were elevated to approximately their present outlines, the known geologic history of the West Indies was just beginning, for the oldest determined rocks belong to the Cretaceous, Tertiary and Pleistocene ages. The Greater Antilles at the close of the Cretaceous period formed a region of volcanic activity for vast heaps of land-derived gravel and the conglomerate which make the great thicknesses of old sedimentary rock in the Antillean mountains lead to the conclusion that at the beginning of Tertiary time there were land areas in the West Indies. A great revolution followed. The pre-existing lands were depressed beneath the sea to great depths, in places five miles, or more, until only the high land re-

1) Ortmann, A. E.: The geographical Distribution of freshwater Decapods and its Bearing upon ancient Geography. Proceedings American Philosophical Society XLI: 347. April—December 1902.

mained above the sea to form a series of small islands during the second quarter of Tertiary history. In the third quarter, another revolution occurred by which the floor of the ocean was corrugated into land, and the old sediments with the deep sea muds and chalks were folded into the gigantic Antillean mountain systems, which at this time probably reared their summits to an elevation of twenty thousand feet and over, connecting all the Antilles into a single body of land. Another general subsidence followed in the last quarter of Tertiary time. It was sufficient to break up the Antillean land mass into the present island groups. During this the island of Jamaica, as the character of the land-snail fauna shows, as well as the depth of the channel between it and Haiti was first to be isolated, then Cuba, and afterwards Santo Domingo and Puerto Rico were separated. The connection between the Antilles and the mainland was broken and the Bahaman region was submerged. The subsidence continued until only the summits of the Antillean Mountains remained above water. Then followed another period of elevation which has lasted until the present. The Bahamas have emerged above the sea, either by elevation or growth, and have been tenanted by forms drifted from Cuba and Santo Domingo, while some have colonized recently in south Florida. There is, however, no reason to suppose that the two great basins the Gulf of Mexico and the Caribbean Sea, at any time lost their general integrity, or connection with the ocean, although their limits were altered and although at times the Pacific probably invaded.

Collectively the Greater Antilles, from a physiographic standpoint, consist of a disconnected chain of mountains with an east-west trend. The highest peaks of this system in Haiti, Cuba and Jamaica are 10,300, 8000 and 7000 feet respectively. The higher mountains above 2000 feet are composed of non-calcareous clay and conglomerate, largely the debris of unknown lands of pre-Tertiary time, which were buried beneath the sea in early Tertiary time to be lifted up later covered by a vast accumulation of oceanic sediments, which compose the white limestones which constitute the chief formations of the islands and occur in horizontal benches or terraces. Instrusions of igneous rocks, granite porphyry and basalt are found.

A more or less continuous chain, the Antillean Mountains, extend in a westward direction from St. Thomas through Puerto Rico, Santo Domingo, the northwest cape of Haiti, the Sierra Maestra range of Cuba to run beneath the sea in the Misterosa Bank of the Caribbean Sea. Santo Domingo is the center of the island chain reaching in Mount Tina an altitude of 10,300 feet (3140 m). The Sierra de Cibao is the principal range in the island. It is flanked on the north by the Monte Christi range with an outlier toward the southwest and by a fourth mass of tall mountains which from the axis of the southwestern peninsula in Haiti. The latter extends toward Jamaica and is continued through that island as the Blue Mountains in Honduras. The north branch is a part of the main, or axial range which is represented in Cuba by the lofty summits of Sierra Maestra, bordering on the Santiago coast of

the east end of the island. Although apparently it ceases at Cape Cruz, it is continued as the Misterosa Bank, which barely reaches the surface of the water, but yet rises precipitously 18,000 feet from the bottom of the sea. — The islands of the Greater Antilles are not exclusively mountainous. There are numerous valleys, plains and plateaus, often of wide extent and great fertility, which will be mentioned in our description of the various islands.

## a. Virgin Islands and St. Croix.

East of Puerto Rico stretches a group of islands known by the name of Virgin islands. The principal islands are Vieques and Culebra belonging to the United States, St. Thomas and St. John belonging to Denmark, Tórtola, Virgin Gorda and Anegada belonging to England. The islands of the group are mountainous and project above the water like submerged peaks, which they actually are, representing a submarine prolongation of the mountains of Puerto Rico. The submarine bank of which these islands form the upper projections is only 6 to 20 fathoms deep between the various islands of the chain. The total area of the islands hardly aggregates two hundred square miles, the largest island, St. Thomas having a superficial extent of only thirty-seven square miles (96 qkm). The highest point on St. Thomas is 1550 feet (472 m), on Tortola 1780 feet (543 m), whilst hills in Vieques and Culebra are only 500—600 feet high, while Anegada (Spanish inundated) is elevated only a few feet above sea-level. The central islands present the appearance of a steep ridge, precipitously sloping to the north and the south, and cut by ravines, which during heavy rains are the beds of small torrents which are dry in ordinary weather. The lower ends of these streams beds widen into level tracts on the sea-coast forming a lagoon on the sandy shore. The coast between these level plains is generally bold and rocky, forming picturesque promontories.

These islands are all of the same general geologic composition as the Greater Antilles consisting of a foundation of rocks of probable Paleozoic origin, covered by masses of Cretaceous and Tertiary conglomerates, and clay derived from the vanished West Indian-Central American continent. These rocks are superficially covered by oceanic chalky-white limestones, which are in turn fringed by coral-reef rock, while dikes of ancient volcanic material penetrate the older rocks. The soil with the exception of that of Vieques is a red heavy clay.

St. Croix lies to the south of the Virgin islands and is separated from them by an immense chasm more than 2000 fathoms deep. The island is 83 square miles (215 qkm) in area and has a high sharp configuration, with deep cliffs near the shore and many low hills in the interior. The northern and southern shores approach each other toward the eastern end, where the meet in a rounded point. The north side is hilly and broken, with one well-defined valley, that of the Salt River. The eastern end has hills 600 feet high and is surrounded by a shoal five to eight fathoms deep. Hills are found

also at the north-western end, which is steep too, while the southwestern point forms a low sand spit with shallow water for some distance from the shore. Along the coast line of the island occur alluvial formations often enclosing lagoons, which are gradually being filled with vegetable matter.

### b. Puerto Rico.

Although this island nowhere attains the elevation of the mountains of Haiti and Jamaica, it is practically the eastern extension of the Antillean series of uplift. It rises from a submerged bank which borders it for a few miles and is continued across to the other islands. On the north slope, this bank descends almost precipitously to a depth of nearly 30,000 feet (9140 m) into what is known geographically as the Brownson Deep. The outline is nearly that of a parallelogram and the coast-line is almost perfectly straight, although there are a few headlands. The island landscape is a composite consisting of hills, fertile plains watered with numerous gently flowing streams. The mountains, generally low, rise to El Yunque in the Sierra Luquillo (3609 feet)[1]), the highest peak in the island. The extension of these mountains southward is known as Sierra de Cayey, while westward outlying ridges have various names. The southwestern end is a heaved-up area of mountains, hills, spurs, valleys, from which run down the many streams and rivers of the island, such as the Bayamon, Plata, Cibuco, Arecibo, Camuy which flow north, and the Culebrinas, Anasco, Guanagibo and Mayaguez, which flow west. The Portugues, Jacaguas, Coamo rivers flow west and the Humacao, Naguabo and Fajardo to the east.

The geology of Puerto Rico is very little known. The hills according to Cleve a Swedish geologist are fragments of a very thick series of limestone strata which have been much denuded. The summits of the mountains are capped by the Antillean limestone formations. The presence of fossils shows that these limestones are identical in age with the Tertiary rocks, of the other Antilles. A core of older rocks, conglomerates, etc. are similar to the older rocks of Jamaica. The rocks of the littoral are probably coral and great reefs exist today on the east and south coasts of the island.

### c. Santo Domingo (Hispaniola).

Santo Domingo excels Puerto Rico, Cuba and Jamaica in altitude, diversity of configuration, picturesque aspect and natural fertility[2]). It is continental in its topographic make-up, being the radiating center of the great Antillean uplift. The outline of Hispaniola is the most irregular of all the Greater Antilles, its periphery being nearly a thousand miles (1600 km), its length 400 miles (644 km), and its breadth 160 miles (257 km). The great Gulf of

1) The maps indicate 1520 m near the west coast. (Drd.)

2) HARSHBERGER, J. W.: An ecological Sketch of the Flora of Santo Domingo. Proceedings Academy Natural Sciences Philadelphia 1901: 554—556.

Gonaives is enclosed by the western peninsulas, and is an immense semicircular bay with a coast line of two hundred miles. Samana Bay on the northeast, Barahona Bay on the south coast and Manzanilla Bay on the north are also conspicuous indentations. Approached from the ocean, the island presents a huge mass of mountains rising precipitously from the sea, extending in all directions and apparently jumbled up in hopeless confusion. The mountains consist of lofty forest-covered peaks, resembling the Alleghanies, and Alps or the Pyrenees, but with this difference, that they are always without snow. There are four ranges of mountains which run in a general east-and-west direction, as follows: The northern fragment is the Monte Cristi Range; the main orographic section, the Sierra Cibao, consists of lofty mountains, with the third range as an outlier toward the south-west and the fourth mass is formed by the tall mountains of the southwestern peninsula. Between these ranges lie extensive fertile valleys, threaded by streams of limpid water. Many of these streams debouch on the plains which fringe the sea-coast, and irrigate those coastal areas which are more or less arid in condition, being shut off from the prevailing winds and rains by lofty mountain summits. There are many central valley plains in the island. The largest of these, lying between the Monte Cristi Range and the Cordillera Cibao, extends from the sea at the Haitian border to Samana Bay, its eastern prolongation. The western portion, watered by the Yaqui, is an arid region covered by chaparral, where arborescent opuntias and cereuses abound. The windward area, or eastern division, watered by the Yuna, is covered by beautiful deciduous plants. South of the Cibao Range is the extensive plain of Seylo, covered in part by open prairie and forest. The terraced Caribbean coast supports a belt of forest averaging twelve miles in width. The tension line between coastal forest and inland prairie is park-like in aspect, carpeted by green grass and dotted by clumps of trees. At Azua, the whole neighborhood is barren, dry and thorny. The only lakes Assuei and Enriquillo are salt, occupying the east-and-west depression which separates the southern peninsula of Haiti from the main portion of the island. This basin, formerly an oceanic inlet, is said to be inhabited still by sharks, porpoises and even crocodiles.

The configuration of the Haitian division of the island appears an agglomeration of mountains, hills and valleys most irregular in form. There are precipices, deep hollows, vales apparently without outlet, but with water glistening below. The whole of the republic is more or less mountainous. The Hotte Mountains are most noted and they form a continuation of the great axial sierra of the island. There are many beautiful slopes and valleys. Those of Port-au-Prince, Gonaives, Artibonite, Arcahaie, Port Margot, Leogane, Aux Cayes are the most famous. Some large islands are attached to the coast, viz., Tortuga, L'Ile-à-Vache, Gonaive, Beata and Saona. — The coast of Santo Domingo is fringed in many places by coral reefs, that are developed inside the bays. Samana Bay is more than half filled by them, while Gonaive Island is connected on both sides with the shore by reefs broken by a number of passages.

The rivers of Santo Domingo are many. The Rio Yaqui, Chico descends from the Cibao highlands southward to the Caribbean Sea. The Rio Yaqui flows from the same heights northward to the Vega Real and then traverses that depression to Manzanilla Bay. The Manai or Yuna River empties into Samana Bay. They are exceeded in length and volume only by the Artibonite which rises in the central highlands and flows westward through Haiti into the Gulf of Gonaivès. Smaller rivers drain every portion of the island. One of the most copious of these streams is the Ozama upon which the City of San Domingo is founded.

The geology of the island is similar to that of Cuba and Jamaica, more especially according to Hill, the western ends which are composed of four principal formations: the older mountain rocks, of Cretaceous and Tertiary age, made up of igneous rocks and clays, mantled by gravels and crystalline limestone; the white limestones of Tertiary age; recent alluvial formations; and the coast limestone of elevated reef rock. No recent volcanic rocks are known.

## d. Cuba.

The island of Cuba is long and narrow being 730 miles (1170 km), while the breadh averages 80 miles (130 km). The Cuban coast is generally low and flat, and is surrounded by numerous coral reefs and islands, which shut off from the sea a large number of salt lagoons, which are in some cases used to obtain salt by the process of evaporation. Its eastern end is mountainous with the summits standing high above the adjacent seas extending from Cape Maysi to Cape Cruz. These mountains form a chain, known as Sierra Maestra, with such prominent peaks as Pico del Turquino: 8400 feet (2560 m, very near to the southern shore), Gran Piedra: 5200 feet (1585 m), and Ojo del Toro: 3500 (5190) feet, to break the general elevation of the range. A much smaller ridge of less elevation than the main chain follows westward the central line of the island and may be considered as the backbone of it. The central and western parts of the island possesses two formations of compact limestone, one of clayey sandstone and another of gypsum, while caverns are found in the limestone formations. The Sierra Maestra Mountains are composed of non-calcareous conglomerates and shales of Mesozoic and Eocene age, intruded, says Hill, by great masses of dark-colored mid-Tertiary, igneous rocks, the debris of which makes a clay and gravel soil, the whole covered on the seaward face by white limestones to an elevation of 2000 feet or more. The lower slopes are terraced and represent the successive series of elevations which the island has undergone. The Sierra de los Organos occupies the western province of Pinar del Rio extending northeast and southwest and culminates in the Pan de Guajaibon at an altitude of 2532 feet (772 m). Geologically, it is composed of deformed sedimentary rocks of supposed Palozoic, Triassic, Jurassic and Tertiary age.

The rivers of Cuba are short, and flow north and south. The Cauto River is the largest and empties into the Bay of Buena Esperanza on the southern

coast. Sagua la Grande, the North and South Jatibonico, the Cuyaguateje, Zaza, Agabama and Guanabana are also notable streams. The distinct types of relief, then, include regions of high mountains, low hills dissected plateaus, level plains, valleys and coastal swamps. The southern coast produces the extensive cienaga, or swamp, known as the Zapata on the coast opposite Matanzas and continues out into the sea toward the Isle of Pines, which occupies the concave depression of the south coast of the island.

The island from a geologic standpoint consists of an older basement of pre-Tertiary sedimentary rocks in which fossils of Cretaceous and probably Jurassic age occur. Above this are littoral beds, then a thickness of white limestones, as distinguished from true reef rock of late Eocene and Oligocene age. The island was reclaimed from the sea and assumed its present physiographic condition by the great mountain uplift of late Tertiary time, following the deposition of the oceanic limestones. Subsidences and elevations occurred in the Pliocene and Pleistocene, which altered the coastal borders, producing eroded cliffs and elevated reef rock.

## c. Jamaica.

The island of Jamaica is an elevated portion of the submerged bank which extends southwestward from Santo Domingo. Between this island and Cuba occurs the eastern lobe of the great Bartlett Deep, three thousand fathoms. The relief is mountainous, and at a distance from the east the island presents a group of mountain summits rising above the sea in a confused mass without regular ridges or secondary types of relief. Upon a nearer approach, four distinct physiographic types are recognizable. These are (1) the interior mountain ranges constituting the nucleus of the island; (2) an elevated limestone plateau, which surrounds the mountains and ends abruptly toward the sea; (3) the coastal cliffs, or back coast border of the oceanic margin of the plateau; and (4) a series of low level coastal plains around the edge of the island, between the sea and the back coast border.

The plateau is a shelf built out from the mountain masses through which the higher summits project. In the west of the islands, where the limestone becomes dominant, occasional views of the buried mountain formations may be seen, where running water has etched away the superficial limestone deposits. The Blue Mountain ridge found in the eastern interior dominates the topography of that end of the island. It extends in an irregular manner one-third the length of the island culminating in Blue Mountain Peak, 7360 feet (2240 m) high. The elevation of the range decreases west of this peak, until the mountain rocks sink below the limestone hills. West of St. Catherine Peak, 5036 feet (1530 m), the main range forks, the southern branch continuing through St. Andrew Parish. The mountains consist of loosely consolidated shales, conglomerates and clays with occasional limestone beds and dikes of igneous rock. The old formations are seen in some of the great central valleys, where they are exposed by the wearing away of the limestone.

The materials of the marginal table-land are soluble limestones which were formed as calcareous oceanic sediments. The configuration of the hilly country in the western side of the island owes its character largely to the solution of the limestone rock. The summit surface of the plateau is a hilly country filled with sink-holes, or cockpits, which represent deep basin-shaped valleys with deep drainage to the sea. The cockpit country, which has never been crossed, owes its topography to these cockpits, which are separated from each other by rounded conical hills rising above them. The seaward margin of the plateau, according to HILL [1], presents a sloping mountainous front rising to an average altitude of 1200 feet along the north coast. At Montego Bay, it is finely shown in a series of six benches which rise above the sea. The highest of the old benches is John Crow ridge (circa 2100 feet) separated from the Blue Mountains by the deep gorge of the Rio Grande. The next level (1500 feet) is seen in Long Mountain east of Kingston. A third step has an altitude of about 1000 feet and is found on the north side of the island, as a great dissected plain. A lower group of levels are found at 650, 300 and 200 feet, respectively, which have been cut out of the old limestone matrix during a later period of emergence followed by a subsidence.

The lowland of the coast consists of three types of formations, such as elevated reefs, marginal sea debris and alluvial deposits. Liguanea Plain is one of the most important topographic low land features. It is over 25 miles long by 6 miles wide and has an area of 200 square miles (518 qkm). This plain is comparatively bare and sterile, presenting in its xerophytic flora a striking contrast to the flora of the rest of the island. Such a plain, as Liguanea, is a record of four distinct events according to HILL: (1) the original cutting out of the matrix during a period of base leveling: (2) the filling in of the material constituting the present surface; (3) the elevation of the plains into their present position above the sea; and (4) the cutting of the modern streamways across them.

Jamaica abounds in streams of which two hundred have been described. The Rio Cobre drains the beautiful valley of St. Thomas-in-the-Vale by ten affluents which unite in a single trunk stream to flow through the Bog Walk Canyon. Wag Water River drains the northern slopes of the Blue Mountain range. Montego River, Great River and Black River drain the marginal slopes of the Cockpit country. The Minho River is an important stream draining into the Caribbean Sea near Portland Point. Salt River and the Cabaritta on the south side are navigable to barges, while many of the streams are roaring and turbulent in their flow from the highlands of the interior.

In geological conclusion the Blue Mountain series of rocks are of Eocene and Upper Cretaceous age. The older white oceanic limestones are perhaps

1) HILL, ROBERT T.: A Sketch of the Geology of Jamaica. The Scottish Geographical Magazine XV: 631. December 1893; Bulletin of the Museum of Comparative Zoology Harvard College XXXIV.

Oligocene, formed by foramineferous deposits, while the later are Pliocene, Pleistocene and recent age laid down as littoral, or reef material on marginal terraces, which prior to their submergence were probably wave-cut. The first definite evidence of the existence of Jamaica and the other Antillean islands is found in the eruptive rocks of late Cretaceous times, and the land debris constituting the strata of the Eocene testifies to the pre-existence of extensive Cretaceous land areas. A profound subsidence in later Eocene and early Oligocene times submerged all but the summits of the highest Antillean mountains, and this movement extended to the margins of the surrounding continents. A tremendous uplift in late Oligocene, or Miocene times connected many of the islands and perhaps these with Central America without, however, bridging the interval between the North and South American continents. The islands were again severed in the last quarter of Tertiary time by submergence and assumed their present forms, which have been affected subsequently by only secondary modifications. Since then there have been intermittent periods of elevation without serious deformation, but not sufficient to restore the islands to the heights of mid-Tertiary time.

### f. The Bahamas.

This group of islands represents a vast marine bed, or submerged plateau parts of which raised above the surface of the sea as dryland, form an archipelago stretching through a total distance of 780 miles (1255 km) from the eastern coast of Santo Domingo. The archipelago consists of over 690 islands and islets and 2387 rocks. The islands are not composite in construction but according to Professor A. Agassiz, they represent wind-blown piles of shell and coral sand rather than coral-reef rook. More extensive in the past their areas have been restricted by a general regional subsidence of some three hundred feet, so that much of their former surface exists as submarine banks covered by shallow water. The sand, which enters into their constitution, is white shell-sand, the particles formed by the breaking of shells and corals into fragments. Reefs encircle these islands where the coral polyps are still active. The principal islands are grouped together in several natural groups. Thus in the north, we find Great Bahama Island, Great and Little Abaco islands with several cays forming one division. Andros Island, the largest of the Bahamas, with New Providence, Eleuthera, Cat, Great Exuma and Long islands form another group, while Crooked, Acklin, Mariguana, Great and Little Inagua, Turk and Caicos islands form the most southern division of the series. Watling Island, the first land fall of Columbus in 1492, stands by itself in the Atlantic Ocean east of Cat and Long islands. The islands are all low in relief, the highest hill in the whole range of islands is only 230 feet high. The soil, although thin, in very fertile. From the sea, the Bahama islands appear as low stretches of verdure covered land bordered by a strip of white beach before which lies in the open bays water of transparent beauty, so clear, that the socalled sea-gardens of coral and seaweed can be seen at the bottom.

Low rounded hills are seen, typic sand dunes, more rugged on the leeward side. The rock is honeycombed by the weather and is called eolian, and is extremely porous the rain water rapidly percolating through. The Bahamas with the exception of Andros island are destitute of springs, or running streams, the water collecting in underground reservoirs.

### g. The Bermudas.

This small group of islands stands on a marine bed 25 miles long in latitude 32° 20′ N. and longitude 64° 50′ W. about 600 miles (965 km) E. by S. from Cape Hatteras on the American coast. All are of coralline formation and the Bermuda archipelago marks the northern limit of the coral building polyps. The reefs encircling the islands are still growing and leave a few intricate passages where ships can enter. The largest of these islands is Long Island enclosing on the east Harrington, or Little Sound and on the west Great Sound, studded with islets. Boaz, Somerset and Ireland islands protect Great Sound on the north. St. David's, Smith's, Cooper's, Nonsuch, St. George's and Paget's islands lie to the east and form a crescent about Castle Harbor.

White granular limestones of various degrees of hardness with caves eaten into them constitute the geologic material of these islands. The rocks have been formed from wind blown calcareous sand heaped into dunes, which have been consolidated into a porous limestone by the cementing action of rain-water, containing carbon dioxide. By subsequent erosion, soil has been formed from these rocks (usually of a red character), as a one percent residue left after the removal of the limy salts. It represents peroxide of iron, silica and earthy phosphates, sparingly soluble in water. Stream and wells of fresh water are entirely wanting and the people are dependent on the rain water, which they collect and preserve in tanks.

## Chapter II. Climate of North America.

*General remarks.* In dealing with the climate of North America in general, we must consider it from the continental aspect. It is important, therefore, to give a brief summary of the peculiarities of the climatology of large continents before the tables and data of temperature, precipitation and other meteorologic phenomena are presented.

A common feature of continental climates in all latitudes is their large range of temperature. Marine climates, including those of oceanic islands, on the other hand are characterized by a small annual range. A continental climate is, therefore, considered to be severe as regards its temperature conditions, while a marine climate is mild by contrast. The annual temperature curve of continental and marine climates is of a different type. In continental climates, the maximum temperature comes about one month after the date of the sun's maximum altitude, while the minimum temperature is similarly, though to a

less marked degree delayed after the sun's lowest altitude. In marine climates on the other hand, the delay in the time of maxima and minima is much greater. The lowest temperature does not occur until two, or even three, i.e., in February and March. The highest temperature is similarly delayed after the greatest altitude of the sun, although to a less degree, the warmest month being August.

The covering of snow in the northern part of North America has an important influence on climate, because it alters the effect which land has upon the temperature of the air by substituting its own influence for that of the ground which has then no control over the temperature of the air. Snow during the season of frost increases radiation and at the same time prevents the flow of heat from the ground by conduction, and in this respect, it is very beneficial. For this reason, says HANN, radiation from a snow surface under the clear sky of a continental winter considerably reduces the winter temperatures and increases the annual range of temperature. The increase of temperature in the spring is much retarded by the presence of snow, because the heat of the sunshine and of the warmer currents of air is almost wholly expended in melting the snow and ice.

The diurnal range of temperature increases with an increase of distance from the ocean, as does the annual range. The greater and more rapid warming of the land surface, and the stronger insolation, increase the daily temperature maxima; while on the other hand the dry air and clear sky at night favor rapid radiation and cooling of the earth's surface, and produce low nocturnal minima. Thus, there is a large diurnal and a large annual range. The diurnal range is greatest on deserts, and especially on dry plateaus. In Death Valley, California, the mean diurnal range of temperature in August, 1891, was 64.2° F. (36° C.) and the greatest daily range in the same month was 73.9° F. (41° C.). The variability of the monthly means of temperature is greater in a continental than in a littoral, or insular climate. Thus in the interior of North America in February, the mean departure is 36.6° F. (20° C.), in August, 33.9° F. (19° C.) and for the year, 35.0° F. (19,5° C.).

With respect to temperature, it may be stated as a general rule that the temperatures in a littoral, or an insular climate possess a greater uniformity than a continental one. This is due, in the first place, to the influence of neighboring large bodies of water and secondly to the moist atmosphere, the effect of which is to minimize the influence of cooling agencies by causing a condensation of water vapor and thus by means of the latent heat liberated diminishing the fall of temperature, which would otherwise take place.

The influence of continents upon humidity, cloudiness and precipitation is marked. As the water vapor of the atmosphere is supplied by evaporation of the ocean waters, the amount naturally decreases toward the interior of the large continents, not considering the local sources of supply such as rivers, lakes and vegetation. The lowest mean annual relative humidities in the United States for instance are in the dry southwest. Yuma, Arizona,

has a mean annual relative humidity of 42.9 per cent. in June. Santa Fe, New Mexico, has a mean annual of 44.8 per cent., with a mean monthly minimum of 28.7 per cent. in June. Pueblo, Colorado, has a mean annual of 46.2 per cent., with a mean monthly minimum of 37.6 per cent. in April while Death Valley, California, has a mean relative humidity of 23 per cent. during five months (May—September) of the year 1891. The atmosphere is very dry, absolutely, over the continents of middle and higher latitudes in winter, on account of the severe cold which then prevails, but it is relatively very moist and near saturation. Under these conditions, the relative humidity does not decrease inland, there it actually increases.

The greater relative dryness of the continental interiors naturally involves *also a smaller amount of cloudiness, especially in summer*. The maximum of cloudiness in the United States is found on the northwestern Pacific coast (65 per cent). The lake region has a mean annual cloudiness of 60 per cent, while the greater part of the middle and south Atlantic coast has a percentage of 50 and over the Mississippi and Missouri valley the average cloudiness is between 45 and 50 per cent. The mean annual cloudiness in southern Nevada, southeastern New Mexico, most of Arizona is 30 per cent. — The amount and frequency of precipitation as a rule decrease inland, but this decrease is so irregular and depends so much upon topography; upon the position of the mountain ranges with respect to the rain-bearing winds that no general statement can be made.

The influence of continents upon winds is of the great climatic importance. Land and sea breezes are local phenomena limited to the seacoasts. With the change from day to night, the relative temperature conditions of land and water are reversed followed by a reversal of the winds. In countries where there is no real winter, these periodic winds blow throughout the year. Thus on the south coast of southern California the sea breeze blows throughout the greater part of the year, weak in winter and strong in summer. In higher latitudes, they occur almost exclusively in the warmer months. Thus on the New Jersey coast of the United States, according to the observations of the writer, the sea breeze begins first over the open ocean, as shown by the sails of ships and the smoke of steamers and gradually works in toward the coast, which it reaches on very warm quiet mornings at about 9 o'clock. Frequently, however, the arrival of the sea breeze is delayed until eleven o'clock, or noon. On several days during one summer, the temperature in the early morning stood at 90° F. (32.2° C.), but with the arrrival of the sea breeze, a drop of from 10—15 degrees F. was recorded with in a period of a little over ten minutes. Lake breezes are also of frequent occurence. An excellent example is described by HAZEN[1]. During the summer of 1882, observations were made at the lake crib, a water-tower station, three

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1) HAZEN, H. A.: Report on wind Velocities at the Lake Crib and at Chicago. United States Signal Services Notes; No. VI. 1883.

miles east of Chicago, in Lake Michigan, and at Chicago, with a view to determining the relation of the wind at the two stations. It appeared that the mean hourly direction of the wind at Chicago, during July of that year, indicated a change from almost due east at 1 P. M., through southeast to almost south at 10 P. M.

The subject of continental winds now concerns us. The warming of the atmospheric strata over an extended land surface is influential in the production of winds. The ascending currents of warm air and descending currents of cool air are established and there results a continuous interchange of air between the upper and lower strata. This play of air currents is interrupted at night, when there is a rapid cooling of the surface of the ground by radiation, while the higher strata of the atmosphere are not correspondingly cooled. A difference of atmospheric pressure results and a movement of air from the ocean toward the continent takes place in a direction opposite to the movement aloft. The air flows from the region of higher pressure to that of lower pressure and deflected in consequence of the earth's rotation, we may expect the following winds around the margins of the continents in summer[1]).

| | West Coast. | North Coast. | East Coast. | South Coast. |
|---|---|---|---|---|
| Northern Hemisphere. . | N.W. | N.E. | S.E. | S.W. |
| Southern Hemisphere. . | S.W. | N.W. | N.E. | S.E. |

Such a circulation of air, as we have described for the larger continents, is known as cyclonic. Cyclonic circulation briefly consists then in the formation of two eddies, an up-draught eddy, the center of low barometric pressures into which and about which the winds circulate spirally, the focus of storm phenomena, called in consequence of the inward motion of its winds, the cyclone and on the other hand, a down-draught eddy, the center of high barometric pressures from out of which and about which the winds move spirally, the focus of clear-weather phenomena, called in contradistinction to the cyclonic eddy, the anti-cyclone. When it is remembered that by reason of cosmic causes the permanent relations of the atmospheric circulation arrange themselves more or less in the form of a belt of anti-cyclones lying over the oceans on or near the tropics, a belt of cyclones near the poles, and in the middle latitudes an eastward drift of migratory cyclones and anti-cyclones, changing in latitude and intensity with the seasons, some idea of the mechanism of the circulation that produces weather and conditions of climate is given. The only additional important fact to bear in mind is that the winds of summer are different from those in winter in consequence of the fact that the land is colder than the ocean, and that the air from the oceans flows in aloft towards the continents. The socalled cold and hot waves of the United States are a result of the cyclonic and anticyclonic movements of the atmosphere. For example, the

1) Hann, Julius: *Handbook of Climatology.* Engl. transl. 1903: 165.

location of the center of extreme heat will be found generally on the northern and western outskirts of the area of high pressure. The longevity of the hot wave, which is so detrimental to vegetation, seems to depend upon a slacking up in the general circulation. Aside from the direct heating from the sun, dynamic heating and lack of radiation have an important influence in maintaining the temperature at an abnormal figure. Hot waves according to Professor BIGELOW come from two sources. They originate in a mass of heated air on the Rocky Mountain plains and gradually move eastward from thence; on the other hand, a high area settling over the South Atlantic and Gulf states has the effect of charging the stagnant air with heat, as if the eastward circulation in the upper air was suspended for quite long intervals of time[1]).

The cold wave is remarkably well developed in the winter storms of the central and eastern parts of North America. When supplied by an area of strong high pressure in the northwest, it sweeps down from the cold plains of farther Canada and brings with it the low temperature of that bleak region. Its movement, obliquely towards the cyclonic center that it follows, is accelerated by the winter high pressure characteristic of its source in the continental center and it is nowhere impeded by transverse mountain ranges. Near the track of the cyclone, the cold wave arrives suddenly and in almost fully-developed strength displacing the antecedent warm spell in a few hours and causing an abrupt fall of temperature. This fall of temperature in the spring is especially destructive to all kinds of vegetation. The deforestation of Michigan is said to have given more ready access to cold waves, hence the peach crop has nearly disappeared from that state.

The advent of spring in northern latitudes is dependent on the relative distribution of the cyclonic and anticyclonic areas. The advent of spring is due to the heat that causes the snows to disappear and external manifestations of life to appear in the plant. The temperature of 6° C., or 42.8° F., is that at which the protoplasm of most plants becomes inactive. The advent of spring is considered as taking place at the advent of an isotherm one degree higher 43.8° F. (6.6° C.). The progress of the mean isotherm of 43° F. (6.1° C.) may therefore be considered to represent the average advent of spring. — Along the Gulf of Mexico there is no advent of spring wich we find in the north, for on February 1st, the isotherm in question is found crossing the United States from the vicinity of Cape Hatteras on the east to the north of El Paso, then going westward and reaching the Pacific coast at some distance north of San Francisco. In the interval between February 1st and March 1st, however, it begins a rapid advance, and by April 1st, it passes over central New Jersey nearly westward to the vicinity of Denver, here it makes a bend southward in crossing the mountains and passes abruptly northward to the

1) BURROWS, ALVIN T.: Hot Waves: Conditions which produce them, and their effect on Agriculture. Yearbook United States Department Agriculture 1900: 334.

Pacific Ocean. By May 1st the whole territory of the United States is covered by spring and spring has advanced by May 1st into Ontario and Quebec in Canada. Various fluctuations occur due to the progress of cold waves across the continent, when according to ancient cult the ice saints Sts. Pancras, Servatius and Boniface may be said to reign and frost may be expected in the month of May. From observations extending over a period of fifteen years, the southern limit of probable frost is represented by a line which begins at Cape Cod, passes down the coast to about central New Jersey, thence westward and southwestward, leaving the city of Cairo to the south, thence obliquely through Arkansas into Texas, crossing the Rio Grande and bending abruptly northwestward disappears in the Pacific Ocean. With this brief but comprehensive review of the continental climate of North America the particular climate of the country will be presented.

## 1. Canada.

The climate of Canada is characterized by great heat in summer and a much lower temperature in winter than in corresponding European latitudes. The severity of the winter, as tested by the thermometer, leads to a very exaggerated impression of the subjective climatic conditions. Owing to the dry, clear, bracing atmosphere which generally prevails, the sense of discomfort is rarely experienced in a Canadian winter. There are indeed, every winter, a few days of intense cold, as in the summer there are brief periods of equally intense heat. But throughout the greater part of the winter season in the Dominion, the sky is bright and clear and the weather thoroughly enjoyable. Snow brings with it all the pleasures accompanying sleighing, skeeing and skating, while the farmer hails the snow as highly beneficial and protective to his crops. In the province of Quebec, the snow begins to lie early in November, in Ontario it is fully a month later, and it differs correspondingly at various localities throughout the country. According to the meteorologic records, January and February are the coldest months of the year. Throughout the whole of Canada steady sleighing is reckoned upon during these months. Snow finally disappears in Quebec about the middle of April and in Ontario about a month earlier. In Nova Scotia, New Brunswick, and Prince Edward Island and on the Pacific slope, the climate is controlled by nearness to the open seas. Spring passes rapidly. Harvest begins before the end of July and with the rapidity of growth under the warm Canadian skies other crops follow in rapid succession until the autumn sowing of wheat is followed by the early oncoming of winter. In this way the Canadian climate is marked by the striking contrast of two seasons, summer and winter and this characteristic seems to be general for Manitoba presenting no marked diversity from Quebec, or Ontario. Spring glides insensibly into summer, summer into fine autumn weather, which, during the equinox, breaks up in a series of heavy gales of wind accompanied by rain and snow. Then follows Indian summer and the long steady winter of the Canadian year.

**Data furnished by the Canadian Meteorologic Service, 1903[1].**

| January. | Temperature (F.). | | | | Precipitation. | | Depth of snow. | | |
|---|---|---|---|---|---|---|---|---|---|
| Stations. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | January. | February. | March. |
| | ° | ° | ° | ° | Ins. | Ins. | Ins. | Ins. | Ins. |
| St. Johns, N. F. | ..... | ..... | ..... | ..... | ..... | ..... | .... | 22.1 | 4.6 |
| Sydney, C. B. I. | 27.0 | + 0.5 | 28.9 | 13.2 | 6.18 | + 1.08 | 33.0 | 24.5 | 8.0 |
| Halifax, N. S. | 25.3 | + 3.5 | 33.1 | 17.6 | 5.09 | − 0.68 | 16.8 | 16.9 | 8.2 |
| Grand Manan, N. B. | 24.5 | + 1.1 | 32.5 | 16.4 | 4.71 | − 0.20 | 11.8 | 9.0 | 3.5 |
| Yarmouth, N. S. | 28.3 | + 2.0 | 34.9 | 21.7 | 5.30 | − 0.11 | 13.5 | 10.6 | 1.3 |
| Charlottetown, P. E. I. | 17.9 | + 0.9 | 25.8 | 10.0 | 2.85 | − 1.11 | 20.7 | 17.7 | 9.3 |
| Chatham, N. B. | 11.8 | + 2.0 | 22.5 | 1.2 | 3.28 | − 0.31 | 20.3 | 33.7 | 12.9 |
| Father Point, Que. | 12.4 | + 4.4 | 20.0 | 4.7 | 4.26 | + 1.41 | 42.1 | 38.8 | 10.6 |
| Quebec, Que. | 11.0 | + 1.9 | 18.5 | 3.5 | 3.37 | − 0.64 | 29.0 | 39.2 | 5.2 |
| Montreal, Que. | 14.3 | + 2.6 | 21.6 | 7.0 | 4.08 | + 0.35 | 33.4 | 26.5 | 3.1 |
| Bissett, Ont. | 4.9 | − 1.5 | 18.1 | − 8.3 | 1.34 | − 0.98 | 13.0 | 28.4 | 2.3 |
| Ottawa, Ont. | 11.8 | + 2.2 | 20.4 | 3.2 | 2.82 | − 0.17 | 18.6 | 26.5 | 0.3 |
| Kingston, Ont. | 19.8 | + 2.7 | 27.7 | 11.8 | 2.65 | − 0.80 | 17.8 | 14.5 | 3.3 |
| Toronto, Ont. | 23.1 | + 1.7 | 29.8 | 16.3 | 2.71 | − 0.21 | 20.5 | 13.0 | 0.5 |
| White River, Ont. | 1.0 | + 1.4 | 15.2 | − 13.1 | 1.36 | − 0.33 | 13.6 | 9.8 | 18.0 |
| Port Stanley, Ont. | 23.3 | + 1.1 | 30.2 | 16.5 | 3.11 | + 0.12 | 23.9 | 11.4 | 1.2 |
| Saugeen, Ont. | 22.5 | + 2.1 | 29.9 | 15.1 | 3.82 | − 0.23 | 32.7 | 22.5 | 2.8 |
| Parry Sound, Ont. | 16.4 | + 2.6 | 25.7 | 7.0 | 3.47 | − 0.61 | 23.3 | 22.1 | 8.3 |
| Port Arthur, Ont. | 7.8 | + 4.7 | 17.9 | − 2.2 | 0.23 | − 0.59 | 2.3 | 2.9 | 8.1 |
| Winnipeg, Man. | 2.3 | + 9.1 | 13.6 | − 9.0 | 0.28 | − 0.60 | 2.8 | 1.0 | 9.7 |
| Minnedosa, Man. | 3.5 | + 10.7 | 15.1 | − 8.1 | 1.13 | + 0.33 | 11.3 | 2.9 | 4.6 |
| Qu'Appelle, Assin. | 5.9 | + 9.7 | 15.7 | − 4.0 | 1.10 | + 0.60 | 11.0 | 1.2 | 3.6 |
| Medicine Hat, Assin | 18.9 | + 13.4 | 29.8 | 8.1 | 0.25 | − 0.32 | 2.5 | 3.0 | 2.5 |
| Swift Current, Assin. | 15.1 | + 12.0 | 24.4 | 5.8 | 0.70 | + 0.06 | 6.6 | 5.6 | .... |
| Calgary, Alberta | 21.6 | + 13.2 | 31.3 | 11.9 | 0.05 | − 0.48 | 0.5 | 5.0 | 10.0 |
| Banff, Alberta | 18.3 | + 6.2 | 26.3 | 10.3 | 0.94 | − 0.25 | 9.4 | 4.8 | 38.7 |
| Edmonton, Alberta | 12.8 | + 11.0 | 22.5 | 3.1 | 0.97 | + 0.29 | 9.7 | 2.6 | 9.0 |
| Prince Albert, Sask. | 2.5 | + 10.9 | 13.3 | − 8.2 | 0.59 | − 0.38 | 5.9 | 2.1 | 15.5 |
| Battleford, Sask. | 2.7 | + 8.6 | 12.5 | − 7.2 | 0.89 | + 0.49 | 8.9 | 0.4 | 8.2 |
| Kamloops, B. C. | 28.1 | + 5.1 | 33.8 | 22.5 | 0.35 | − 0.47 | 3.5 | 0.0 | 4.6 |
| Victoria, B. C. | 41.9 | + 3.4 | 45.2 | 38.6 | 3.94 | − 1.45 | 0.0 | 1.4 | 9.4 |
| Barkerville, B. C. | 19.3 | + 1.5 | 26.9 | 11.7 | 1.40 | − 1.20 | 14.0 | 4.0 | 16.0 |

| April. | Temperature (F.). | | | | Precipitation. | | | Precip. May. | | | Precip. June. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stations. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | Depth of snow. | Total. | Departure from normal. | Depth of snow. | Total. | Departure from normal. |
| | ° | ° | ° | ° | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| St. Johns, N. F. | 35.1 | + 0.6 | 41.6 | 28.6 | 5.07 | + 0.91 | 0.2 | ..... | ....... | ..... | 1.84 | − 1.76 |
| Sydney, C. B. I. | 37.0 | + 2.0 | 44.5 | 29.5 | 6.37 | + 2.52 | 3.5 | 1.66 | − 2.11 | ..... | 1.38 | − 1.85 |
| *Halifax, N. S.* | *40.6* | *+ 2.8* | *48.6* | *32.5* | *5.52* | *+ 1.34* | *1.1* | *0.67* | *− 3.59* | ..... | 3.49 | − 0.27 |
| Grand Manan, N. B. | 41.2 | + 2.0 | 48.5 | 34.0 | 5.36 | + 2.40 | 4.5 | 4.99 | + 1.38 | ..... | 2.01 | − 0.93 |
| Yarmouth, N. S. | 41.5 | + 2.6 | 48.5 | 34.6 | 6.15 | + 2.76 | 4.1 | 0.93 | − 2.87 | ..... | 6.68 | + 3.92 |
| *Charlottetown, P. E. I.* | *36.6* | + 1.4 | *43.7* | 29.5 | 4.37 | + 1.72 | 10.3 | 0.83 | − 2.08 | 0.8 | 2.24 | − 0.43 |
| Chatham, N. B. | 37.9 | + 2.4 | 47.9 | 27.9 | 3.80 | + 1.17 | 15.6 | 1.37 | − 1.84 | T. | 2.52 | − 0.94 |
| Father Point, Que. | 34.9 | + 1.7 | 42.1 | 27.7 | 3.05 | + 1.47 | 20.2 | 1.27 | − 1.31 | ..... | 2.29 | − 0.69 |
| Quebec, Que. | 39.1 | + 4.0 | 47.4 | 30.9 | 1.76 | − 0.33 | 5.1 | 0.76 | − 2.32 | ..... | 3.51 | − 0.14 |
| Montreal, Que. | 44.1 | + 4.4 | 53.1 | 35.1 | 2.22 | − 0.02 | 4.3 | 0.11 | − 2.84 | ..... | 4.76 | + 1.23 |
| Bisset, Ont. | 40.3 | + 2.4 | 54.7 | 25.9 | 1.12 | − 0.44 | 1.0 | 1.99 | − 0.52 | ..... | 3.98 | + 0.82 |
| Ottawa, Ont. | 44.1 | + 4.1 | 55.0 | 33.3 | 0.95 | − 0.55 | 1.0 | 0.12 | − 2.47 | T. | 6.55 | + 3.63 |
| Kingston, Ont. | 42.3 | + 2.3 | 50.8 | 33.8 | 3.22 | + 1.43 | 1.1 | 0.52 | − 2.16 | ..... | 6.16 | + 3.73 |
| Toronto, Ont. | 43.9 | + 3.1 | 52.7 | 35.0 | 3.74 | + 1.37 | 3.0 | 1.80 | − 1.24 | 0.1 | 3.25 | + 0.45 |
| White River, Ont. | 31.2 | − 1.8 | 43.5 | 18.9 | 1.48 | + 0.23 | 13.8 | 4.96 | + 3.01 | 2.2 | 1.63 | − 0.59 |
| Port Stanley, Ont. | 44.2 | + 3.2 | 51.2 | 37.1 | 3.88 | + 1.41 | 3.3 | 3.27 | + 0.09 | T. | 3.42 | + 0.69 |
| Saugeen, Ont. | 42.5 | + 3.8 | 51.8 | 33.2 | 0.95 | − 0.85 | 0.3 | 1.73 | − 0.71 | 0.2 | 2.03 | − 0.32 |
| Parry Sound, Ont. | 42.1 | + 4.5 | 53.4 | 30.8 | 1.88 | − 0.03 | T. | 2.75 | − 0.18 | ..... | 2.57 | + 0.15 |
| Port Arthur, Ont. | 35.2 | + 1.7 | 43.9 | 26.6 | 1.81 | + 0.09 | 15.8 | 3.17 | + 1.02 | 0.3 | 1.60 | − 1.13 |
| *Winnipeg, Man.* | 40.0 | *+ 4.1* | *52.6* | *27.4* | *0.54* | *− 0.51* | *0.4* | 3.40 | *+ 1.12* | ..... | 0.49 | − 2.80 |
| Minnedosa, Man. | 39.6 | + 3.6 | 52.1 | 27.1 | 1.05 | − 0.01 | 7.9 | 4.65 | + 3.20 | ..... | 1.03 | − 1.97 |
| Qu'Appelle, Assin. | 40.2 | + 2.8 | 53.9 | 26.5 | 0.39 | − 0.66 | 2.3 | 3.86 | + 2.21 | 1.2 | 1.46 | − 1.96 |
| Medicine Hat, Assin | 44.1 | − 0.4 | 58.3 | 29.9 | 0.45 | − 0.29 | 1.0 | 4.19 | + 2.88 | 5.5 | T. | − 2.76 |
| Swift Current, Assin. | 42.3 | + 1.0 | 54.7 | 29.8 | 0.85 | − 0.08 | 3.6 | 3.23 | + 1.47 | 12.4 | 2.26 | − 0.41 |
| Calgary, Alberta | 37.5 | − 2.1 | 49.1 | 25.9 | 0.46 | − 0.18 | 2.6 | 4.25 | + 2.48 | 31.9 | 2.05 | − 0.40 |
| Banff, Alberta | 32.3 | − 3.0 | 42.1 | 22.5 | 1.07 | − 0.01 | 6.5 | 0.94 | − 1.10 | 6.1 | 1.90 | − 1.43 |
| Edmonton, Alberta | 37.8 | − 2.1 | 48.5 | 27.0 | 1.20 | + 0.32 | 10.7 | 1.21 | − 0.34 | 5.7 | 4.94 | + 2.08 |
| Prince Albert, Sask. | 33.7 | − 2.4 | 46.3 | 21.2 | 1.41 | − 0.58 | 13.0 | 2.08 | + 0.82 | 2.1 | 1.07 | − 1.44 |
| Battleford, Sask. | 36.2 | − 1.0 | 47.8 | 24.5 | 1.15 | + 0.68 | 6.9 | 3.70 | + 2.08 | 3.1 | 2.00 | − 1.31 |
| Kamloops, B. C. | 47.0 | − 1.9 | 57.9 | 36.1 | 0.28 | − 0.11 | 0.0 | ...... | ....... | ..... | 0.61 | − 0.81 |
| Victoria, B. C. | 46.5 | − 0.3 | 52.7 | 40.3 | 1.39 | − 0.98 | 0.0 | 0.79 | − 0.69 | ..... | 0.67 | − 0.53 |
| Barkerville, B. C. | 31.3 | − 1.8 | 41.7 | 20.8 | 2.86 | + 1.04 | 23.0 | 2.78 | + 0.26 | 5.0 | 3.58 | + 0.10 |

1) For stations the rainfall is given in inches and tenths when appreciable; otherwise a "trace" is indicated by a capital T and "no rain" by O.o.

| July. | Temperature (F.). | | | | Precipitation. | | Precip. August. | | Precip. September. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stations. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | Total. | Departure from normal. | Total. | Departure from normal. | Depth of snow. |
| | o | o | o | o | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| St. Johns, N. F. | 54.1 | − 5.2 | 61.6 | 46.7 | 3.48 | − 0.41 | 2.32 | − 1.76 | 3.57 | − 0.14 | .... |
| Sydney, C. B. I. | 61.1 | − 1.2 | 70.3 | 52.0 | 2.78 | − 0.87 | 1.66 | − 1.96 | 4.50 | + 1.22 | .... |
| Halifax, N. S. | 61.9 | − 1.5 | 69.7 | 54.1 | 4.37 | + 0.27 | 4.25 | − 0.10 | 4.23 | + 0.52 | .... |
| Grand Manan, N. B. | 61.3 | − 0.4 | 60.4 | 53.1 | 3.87 | + 0.87 | 2.08 | − 1.58 | 1.97 | − 1.20 | .... |
| Yarmouth, N. S. | 60.3 | + 0.8 | 66.8 | 53.8 | 3.50 | − 0.66 | 4.66 | + 0.65 | 4.97 | + 1.52 | .... |
| Charlottetown, P. E. I. | 65.0 | + 0.9 | 74.0 | 56.0 | 3.22 | − 0.27 | 2.22 | − 1.52 | 4.17 | + 0.77 | .... |
| Chatham, N. B. | 63.7 | − 1.3 | 73.8 | 53.5 | 5.57 | + 1.38 | 5.03 | + 0.00 | 2.05 | − 0.66 | .... |
| Father Point, Que. | 54.9 | − 2.7 | 61.8 | 48.0 | 4.40 | + 1.36 | 5.12 | + 2.07 | 0.74 | − 2.39 | .... |
| Quebec, Que. | 64.6 | − 0.9 | 73.1 | 56.0 | 5.09 | + 0.83 | 2.10 | − 1.73 | 1.14 | − 2.53 | .... |
| Montreal, Que. | 68.2 | − 0.3 | 75.5 | 60.9 | 2.87 | − 1.42 | 3.17 | − 0.40 | 1.26 | − 2.04 | .... |
| Bisset, Ont. | 64.5 | − 1.1 | 76.5 | 52.5 | 4.17 | + 1.05 | 4.00 | + 1.05 | 2.70 | − 0.58 | .... |
| Ottawa, Ont. | 68.5 | − 1.0 | 76.7 | 60.3 | 3.24 | − 0.23 | 4.00 | + 0.97 | 2.14 | − 0.55 | .... |
| Kingston, Ont. | 67.0 | − 1.2 | 74.3 | 59.6 | 4.01 | + 1.12 | 3.85 | + 1.47 | 1.11 | − 1.69 | .... |
| Toronto, Ont. | 69.1 | + 1.1 | 79.1 | 59.2 | 4.41 | + 1.40 | 3.67 | + 0.01 | 0.42 | − 2.83 | .... |
| White River, Ont. | 60.5 | + 1.0 | 73.8 | 47.2 | 3.21 | + 0.41 | 3.03 | − 0.27 | 3.08 | + 0.31 | 0.7 |
| Port Stanley, Ont. | 67.7 | − 0.1 | 77.0 | 58.0 | 8.10 | + 5.06 | 3.00 | + 0.58 | 2.02 | − 0.71 | .... |
| Saugeen, Ont. | 66.9 | + 2.2 | 74.6 | 59.2 | 2.23 | + 0.25 | 4.00 | + 1.75 | 5.05 | + 2.11 | .... |
| Parry Sound, Ont. | 65.9 | − 0.1 | 75.2 | 56.6 | 2.89 | + 0.27 | 3.56 | + 0.84 | 4.55 | + 0.88 | .... |
| Port Arthur, Ont. | 61.8 | − 0.2 | 72.2 | 51.5 | 3.29 | − 0.19 | 1.97 | − 0.78 | 5.56 | + 2.08 | .... |
| Winnipeg, Man. | 65.4 | − 0.6 | 77.8 | 52.9 | 3.05 | − 0.03 | 2.00 | − 0.67 | 2.77 | + 0.74 | .... |
| Minnedosa, Man. | 62.1 | − 0.1 | 73.3 | 50.9 | 3.40 | + 0.80 | 3.94 | + 1.84 | 2.16 | + 0.80 | 5.8 |
| Qu'Appelle, Assin | 60.6 | − 2.9 | 71.7 | 49.4 | 4.26 | + 1.78 | 5.03 | + 3.39 | 0.02 | − 0.41 | 3.2 |
| Medicine Hat, Assin | 65.4 | − 2.4 | 78.5 | 52.4 | 1.39 | − 0.70 | 1.80 | + 0.13 | 0.65 | − 0.53 | .... |
| Swift Current, Assin | 62.6 | − 3.9 | 74.3 | 50.9 | 4.11 | + 1.67 | 3.04 | + 1.13 | 1.04 | − 0.18 | .... |
| Calgary, Alberta. | 56.8 | − 3.8 | 69.1 | 44.5 | 4.10 | + 1.42 | 7.70 | + 5.56 | 1.81 | + 0.45 | 4.0 |
| Banff, Alberta. | 53.5 | − 3.1 | 65.6 | 41.4 | 5.70 | + 2.46 | 3.75 | + 1.22 | 2.68 | + 1.01 | 3.0 |
| Edmonton, Alberta. | 59.2 | − 1.4 | 70.1 | 48.4 | 3.45 | + 0.42 | 4.33 | + 2.20 | 1.12 | − 0.21 | 0.4 |
| Prince Albert, Sask. | 58.9 | − 3.0 | 70.3 | 47.5 | 2.96 | + 0.91 | 2.22 | + 0.07 | 2.17 | + 0.89 | 8.0 |
| Battleford, Sask. | 60.8 | − 3.9 | 71.4 | 50.1 | 2.50 | − 0.16 | 2.25 | − 0.11 | 1.01 | − 0.24 | .... |
| Kamloops, B. C. | 67.3 | − 1.2 | 79.8 | 54.9 | 2.33 | + 0.72 | ...... | ...... | 2.34 | + 1.49 | .... |
| Victoria, B. C. | 58.2 | − 1.8 | 64.5 | 51.9 | 0.46 | + 0.66 | 1.06 | + 0.46 | 3.76 | + 1.60 | .... |
| Barkerville, B. C. | 52.3 | − 2.8 | 64.8 | 39.7 | 3.77 | + 0.75 | 6.42 | + 3.32 | 7.74 | + 4.83 | T. |

| October. | Temperature (F.). | | | | Precipitation. | | Depth of snow. | | |
|---|---|---|---|---|---|---|---|---|---|
| Stations. | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. | October. | November. | December. |
| | o | o | o | o | Ins. | Ins. | Ins. | Ins. | Ins. |
| St. Johns, N. F. | 42.9 | − 2.5 | 48.4 | 37.3 | 5.43 | + 0.08 | ..... | 0.0 | 26.0 |
| Sydney, C. B. I. | 46.5 | 0.0 | 53.4 | 39.6 | 5.75 | + 1.06 | ..... | 3.5 | 19.0 |
| Halifax, N. S. | 49.2 | + 2.0 | 57.1 | 41.4 | 6.38 | + 0.83 | T. | 3.7 | 13.8 |
| Grand Manan, N. B. | 48.5 | + 1.6 | 51.0 | 42.9 | 4.85 | + 0.14 | 2.0 | 2.5 | 3.5 |
| Yarmouth, N. S. | 48.5 | + 0.9 | 55.7 | 41.2 | 5.77 | + 1.07 | 0.3 | 6.6 | 28.3 |
| Charlottetown, P. E. I. | 46.0 | − 0.5 | 52.8 | 39.1 | 3.66 | − 1.24 | T. | 6.8 | 24.4 |
| Chatham, N. B. | 44.1 | + 1.1 | 53.4 | 34.7 | 3.45 | − 0.41 | 0.4 | 25.4 | 20.4 |
| Father Point, Que. | 41.5 | + 1.7 | 48.6 | 34.4 | 1.92 | − 0.98 | 0.5 | 16.5 | 28.6 |
| Quebec, Que. | 44.4 | + 2.0 | 50.9 | 37.8 | 2.23 | − 0.92 | 1.5 | 9.7 | 22.6 |
| Montreal, Que. | 48.9 | + 4.1 | 55.9 | 41.9 | 3.70 | + 0.57 | 1.5 | 5.4 | 38.5 |
| Bisset, Ont. | 43.4 | + 0.6 | 56.1 | 30.7 | 1.43 | − 1.00 | 0.4 | 6.9 | 29.1 |
| Ottawa, Ont. | 48.9 | + 5.1 | 57.0 | 40.8 | 3.51 | + 0.96 | T. | 3.0 | 19.8 |
| Kingston, Ont. | 51.3 | + 4.3 | 58.6 | 43.9 | 3.22 | + 0.49 | 1.4 | 3.1 | 19.4 |
| Toronto, Ont. | 50.8 | + 4.2 | 59.5 | 42.1 | 2.77 | + 0.41 | 1.2 | 2.4 | 9.5 |
| White River, Ont. | 39.5 | + 2.4 | 52.0 | 26.9 | 2.54 | + 0.19 | 2.0 | 11.8 | 16.8 |
| Port Stanley, Ont. | 50.5 | + 2.7 | 58.6 | 42.4 | 2.60 | − 0.38 | 3.6 | 0.8 | 20.6 |
| Saugeen, Ont. | 49.6 | + 3.5 | 57.7 | 41.6 | 2.64 | − 0.53 | 0.3 | 14.5 | 69.8 |
| Parry Sound, Ont. | 47.4 | + 3.5 | 56.4 | 38.4 | 4.79 | + 0.87 | 1.0 | 11.8 | 29.9 |
| Port Arthur, Ont. | 43.4 | + 3.5 | 52.4 | 34.4 | 2.71 | + 0.15 | 1.0 | 0.8 | 1.8 |
| Winnipeg, Man. | 45.0 | + 5.9 | 56.8 | 33.1 | 0.69 | − 1.01 | T. | ..... | 10.2 |
| Minnedosa, Man. | 44.8 | + 7.0 | 56.1 | 33.5 | 1.43 | + 0.23 | 0.0 | 15.0 | 7.7 |
| Qu'Appelle, Assin | 45.5 | + 6.1 | 56.7 | 34.2 | 0.47 | − 0.63 | 1.0 | 11.0 | 9.6 |
| Medicine Hat, Assin | 50.2 | + 5.4 | 65.1 | 35.2 | 0.05 | − 0.53 | 0.5 | 4.5 | 1.0 |
| Swift Current, Assin | 47.0 | + 4.9 | 60.5 | 33.4 | 0.14 | − 0.74 | T. | 4.2 | 6.1 |
| Calgary, Alberta. | 44.6 | + 4.5 | 59.1 | 30.1 | T. | − 0.48 | T. | 6.0 | 1.5 |
| Banff, Alberta. | 41.3 | + 2.0 | 50.7 | 31.9 | 0.72 | − 0.30 | 1.0 | 15.3 | 2.4 |
| Edmonton, Alberta. | 46.2 | + 5.1 | 60.0 | 32.4 | 1.21 | + 0.51 | 7.2 | 7.1 | 5.7 |
| Prince Albert, Sask. | 41.7 | + 4.6 | 52.6 | 30.8 | 1.05 | + 0.22 | 9.0 | 11.6 | 4.0 |
| Battleford, Sask. | 43.4 | + 3.8 | 57.2 | 29.6 | 0.34 | − 0.11 | 0.1 | 7.5 | 3.7 |
| Kamloops, B. C. | 46.5 | − 0.5 | 55.1 | 37.9 | 0.44 | − 0.17 | 0.0 | ..... | 2.4 |
| Victoria, B. C. | 51.2 | + 2.0 | 57.0 | 45.5 | 1.77 | − 0.60 | ..... | 7.7 | 0.0 |
| Barkerville, B. C. | 36.7 | − 3.0 | 43.1 | 30.3 | 0.76 | − 1.94 | 0.8 | ..... | 22.0 |

The hydrography proves that there can be no deficiency in rainfall, for the innumerable lakes and streams are constantly full. In Assiniboia, the great plains project north of the boundary and form an area over 20,000 square miles (51,800 qkm). There are dry belts under the lee of the mountain ranges of British Columbia and a belt of excessive moisture on the Pacific coast. The immense areas of water in the great central lakes alter the climate by imparting humidity to the air and moderating those extremes which are characteristic of a continental climate. The foregoing tables present the details regarding temperature for the four most striking months of the seasons, precipitation or depth of snow for each month of the year, as taken from the U. S. Monthly Weather Review (1903. XXXI). See pages 136—137.

## 2. United States.

The United States, exclusive of Alaska displays nearly all the variations of climate known in the temperate zone[1]. One of the most interesting facts is the low winter temperature of this country as compared with that of the same latitudes in western Europe; for example, the temperature of 32° F. at New York, latitude 40° 43', is met at Hamburg, Germany, 950 miles farther north. The permanent low-pressure area in the North Pacific contributes many of the storms that appear in the extreme northwest. These depressions sometimes reach 29 inches, but, strange to say, they are what may be called dry storms, as they do not gain moisture enough for precipitation in the east until they reach the lake region. Other storms come up from the Gulf of Mexico and pass over the lakes; these give the most abundant precipitation to the country east of the Mississippi River. The lower lake region and the St. Lawrence Valley form the great highway for nearly all the storms of the country (80 to 85 per cent). In the months of August to October, there are peculiar depressions called hurricanes, which are formed in the Caribbean Sea toward the east, and, moving first in a westerly direction, recurve in Florida or the eastern Gulf of Mexico and move up the Atlantic coast, gradually widening and at the same time diminishing in energy.

*Average air pressure.* In the cold months, November to March, the normal charts show areas of high pressure in the south Atlantic states and in the region to the north or west of the middle Rocky Mountains. The latter high area moves east occassionally to the middle and upper Mississippi valleys, and when this is the case the whole country east of the Mississippi is visited by cold weather and temperatures far below the normal. In the remaining months, the Rocky Mountain high area moves to the Pacific and its place is taken by a low area. The second high area moves to the middle Atlantic and sometimes it takes a position to the west of its normal place, in which case the eastern part of the country is brought under the most intense heat. Such was

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1) HAZEN, H. A.: The Climate of the United States. Report International Meteorological Congress, United States Department Agriculture, Weather Bureau. Bulletin II, Part III. *1896*.

notably the case in May, 1881. All the year through there is a permanent low pressure at the mouth of the St. Lawrence, due, in part, to the passage of storms, and, in part, to the permanent low-pressure area over Iceland, or the North Atlantic.

*Winds.* The distribution of the winds is in accordance with that of pressure just given, that is, out of high areas, and around them clock-wise, and into low areas, and around them counter-clockwise. For example, from March to October, the winds are emphatically from the high area in the Pacific, and this explains in part, if not entirely, the lack of rain during these months, for the cool, damp wind of the ocean, has its relative humidity diminished by the heat of the land. The general direction of the wind east of the Rockies, and north of 30° N., is from the west, with the exception that in the lower Mississippi Valley and Texas they are quite constant from the south. Distinctive trade winds are found south of 25° only and these are modified by the permanent high area in the south Atlantic. It may be said, that the upper current is constant from the west over the whole country all the months of the year, excepting a slight tendency in the warmer months for the upper current to coincide with the lower in the tradewind region. The wind on Pikes Peak, latitude 38° 50′ (14,147 feet), averages N. 82° W. a very little south of that in the warm months and north in the opposite season. On Mount Washington, latitude 44° 16′ (6,300 feet) near the Atlantic, the wind is from N. 57° W., steady all the months; N. 48° W. in April and N. 62° W. in June being the extremes.

*Temperature.* The lowest mean January temperature is — 5° F. (— 20.5° C.) in the northern portions of North Dakota and Minnesota. This makes a gradient of 1° F. (0.55° C.) per 25 miles from the Gulf to the extreme northern border, the former temperature being 55° F. (12.8° C.). On the Pacific coast the temperatures are 37° (2.7° C.) to 53° (11.6° C.) from the north to the south, a gradient of 1° F. in 70 miles. On the Atlantic coast, the range is from 20° F. (— 6.6° C.) to 65° F. (18.3° C.), a gradient of 1° F. in 30 miles. The highest mean January temperature is 71° F. (21.6° C.) at Key West. In July, the lowest temperature (56° F. 13.3° C.) is found at Eureka and Tatoosh islands, on the Pacific coast. A temperature of 68° F. (20° C.) at San Diego, California, rises to 92° F. (33.3° C.) at Yuma (the highest in the country at any regular station). The range in the central region is from 66° F. (18.8° C.) to 84° F. (28.8° C.) or a gradient of 1° F. in 85 miles. On the Atlantic coast, the range is from 60° F. (15.5° C.) to 82° F. (27.7° C.) or 1° F. in 57 miles.

*Range of mean temperature from January to July.* The greatest range (72° F.) is found in extreme North Dakota, and the least (8° F.) at Eureka, California. San Francisco has 9° F., Key West 14° F., New York City 43° F., Chicago 48° F. The difference between the normal minimum and normal maximum temperatures will also give an idea of changes of climate. There is only 7° F. at Tatoosh in January, 10° F. at San Francisco, 9° F. at Key West,

16° F. at Chicago, 14° F. at New Orleans and New York, 23° F. at Yuma, and 31° F. the highest in the country, at Pueblo, Colorado. In July, these ranges are nearly the same, save that the highest (36° F.) now appears at Fresno, in central California. In the latter case, the very clear skies of the summer cause intense radiation of heat, and this accounts for the very great difference between the maximum and minimum.

*Individual temperatures.* The lowest temperature at a regular station has been — 55° F. (— 48.3° C.) in the extreme north of Montana, but this has been exceeded at Tobacco Garden, Dakota, — 60° F. (— 51.1° C.). At San Francisco 29° F. (— 1.6° C.); Chicago — 20° F. (— 28.9° C.) (but once in twenty years); New York City — 6° F. (— 21.1° C.); New Orleans 15° F. (— 9.4° C.); Key West 41° F. (5° C.); Washington — 14° F. (— 23.6° C.). The highest temperature observed at a regular station has been 118° F. (47.8° C.) at Yuma, though Furnace Creek has shown 122° F. (50° C.); Mammoth Tank 128° F. (53.3° C.); San Francisco 99° F. (37.2° C.); Chicago 100° F. (37.8° C.); New Orleans 97° F. (36.1° C.); New York City 100° F. (37.8° C.); Washington 103° F. (39.4° C.).

*Number of days below freezing in four cold months.* In southern Florida, extreme southern Texas, and on the Pacific coast of southern California, the temperature does not go below freezing on an average once a year. In Minnesota and North Dakota, 120 times; Chicago 89; New Orleans 5; Washington, D. C. 74; New York City 82.

*Temperature above 90° (32.2° C.), June, July and August.* In Minnesota and North Dakota, from 3 to 7 times; Yuma 90 times; New Orleans 28; St. Louis 24; New York City 4; Washington 10; Key West 3 times in five years.

The following six tables present the average temperature (degrees Fahrenheit) for the five years 1891—1895. In the original tables from which these are condensed observations are recorded for every hour of the day. The elevation of the meteorologic station above tide is also presented in the original[1]). The tables are given by Fahrenheit scale and are not changed to Centigrade scale because all of the records of the United States Weather Bureau are published so. It is, however, easy to convert the tables to Centigrades by subtracting 32 and multiplying by 5/9[2]).

1) MOORE, WILLIS L.: Report of the Chief of the Weather Bureau. 1896—97: 94—107.

2) See also the abstract of this work in german. (Drude.)

Average Temperatures (F.) 1891—1895.

| Stations. | Order following the Mean Minimum[1]). | January. Mean. | January. Mean Maximum. | January. Mean Minimum. | February. Mean. | February. Mean Maximum. | February. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 3 | 9.6 | 16.6 | 5.9 | 7.2 | 16.2 | 7.0 |
| Boston, Mass. | 13 | 28.0 | 34.9 | 20.7 | 27.9 | 34.8 | 20.5 |
| Buffalo, N. Y. | 9 | 25.0 | 29.7 | 18.7 | 24.5 | 30.2 | 17.5 |
| Chicago, Ill. | 5 | 21.9 | 27.6 | 15.0 | 24.4 | 30.5 | 17.6 |
| Cincinnati, Ohio | 16 | 29.8 | 36.2 | 22.9 | 33.9 | 41.2 | 26.6 |
| Cleveland, Ohio | 12 | 25.7 | 31.4 | 19.6 | 27.5 | 34.1 | 21.2 |
| Detroit, Mich. | 7 | 23.2 | 28.8 | 17.1 | 24.7 | 30.0 | 18.4 |
| Dodge City, Kans. | 8 | 28.5 | 41.4 | 18.3 | 28.5 | 40.0 | 18.1 |
| Eastport, Me. | 6 | 22.5 | 28.4 | 15.8 | 22.0 | 27.6 | 14.0 |
| Galveston, Texas | 27 | 53.4 | 58.6 | 47.7 | 54.7 | 59.8 | 49.7 |
| Havre, Mont. | 1 | 15.0 | 20.8 | 2.0 | 10.0 | 22.8 | 3.9 |
| Kansas City, Mo. | 10 | 24.9 | 35.3 | 18.8 | 29.1 | 37.3 | 21.1 |
| Key West, Fla. | 28 | 68.0 | 71.6 | 63.5 | 60.7 | 74.6 | 66.2 |
| Marquette, Mich. | 4 | 14.2 | 22.4 | 9.3 | 14.3 | 23.5 | 8.6 |
| Memphis, Tenn. | 23 | 39.7 | 48.0 | 42.3 | 43.3 | 51.1 | 35.5 |
| New Orleans, La. | 26 | 51.9 | 60.5 | 44.7 | 56.3 | 64.0 | 49.7 |
| New York, N. Y. | 18 | 30.3 | 36.8 | 24.3 | 30.9 | 37.5 | 24.5 |
| Philadelphia, Pa. | 19 | 31.4 | 38.2 | 25.5 | 32.6 | 39.4 | 26.2 |
| Pittsburg, Pa. | 17 | 30.3 | 36.4 | 23.0 | 32.6 | 40.0 | 24.6 |
| Portland, Oreg. | 21 | 38.6 | 44.0 | 33.9 | 39.0 | 45.3 | 39.9 |
| St. Louis, Mo. | 15 | 29.8 | 37.1 | 22.5 | 32.9 | 40.2 | 25.5 |
| St. Paul, Minn. | 2 | 10.8 | 18.0 | 2.3 | 13.9 | 21.7 | 4.7 |
| Salt Lake City, Utah. | 14 | 27.9 | 35.2 | 21.1 | 29.5 | 37.3 | 22.0 |
| San Diego, Cal. | 25 | 53.7 | 63.6 | 44.3 | 54.0 | 61.9 | 45.8 |
| San Francisco, Cal. | 24 | 49.1 | 55.1 | 44.0 | 50.6 | 56.9 | 45.6 |
| Santa Fe., N. Mex. | 11 | 27.5 | 37.4 | 19.1 | 29.8 | 39.2 | 21.5 |
| Savannah, Ga. | 22 | 49.1 | 57.9 | 40.8 | 53.3 | 62.3 | 45.3 |
| Washington, D. C. | 20 | 32.5 | 39.7 | 25.5 | 34.9 | 42.4 | 27.6 |

*Average Temperatures (F.) 1891—1895.*

| Stations. | Order following the Mean Minimum[1]). | March. Mean. | March. Mean Maximum. | March. Mean Minimum. | April. Mean. | April. Mean Maximum. | April. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 1 | 23.7 | 32.9 | 12.2 | 42.0 | 53.6 | 32.7 |
| Boston, Mass. | 12 | 35.3 | 42.2 | 28.8 | 46.3 | 54.8 | 38.7 |
| Buffalo, N. Y. | 6 | 31.9 | 37.9 | 24.3 | 43.6 | 50.8 | 35.5 |
| Chicago, Ill. | 8 | 33.6 | 40.0 | 27.1 | 45.7 | 52.5 | 38.8 |
| Cincinnati, Ohio | 18 | 41.7 | 49.6 | 33.4 | 54.8 | 63.1 | 45.7 |
| Cleveland, Ohio | 9 | 34.2 | 41.3 | 27.2 | 47.3 | 55.1 | 39.3 |
| Detroit, Mich. | 7 | 32.5 | 30.6 | 25.7 | 46.3 | 55.4 | 38.0 |
| Dodge City, Kans. | 10 | 39.8 | 53.1 | 27.5 | 55.4 | 68.9 | 41.2 |
| Eastport, Me. | 5 | 29.6 | 35.1 | 24.0 | 39.0 | 45.9 | 33.2 |
| Galveston, Texas | 27 | 60.4 | 65.6 | 55.5 | 69.4 | 74.0 | 65.4 |
| Havre, Mont. | 2 | 25.8 | 38.8 | 16.2 | 43.6 | 54.3 | 30.2 |
| Kansas City, Mo. | 15 | 40.2 | 49.3 | 31.3 | 55.9 | 65.4 | 46.6 |
| Key West, Fla. | 28 | 72.3 | 76.6 | 68.1 | 75.3 | 79.7 | 71.2 |
| Marquette, Mich. | 3 | 24.8 | 31.2 | 17.0 | 37.1 | 44.4 | 30.6 |
| Memphis, Tenn. | 22 | 50.9 | 60.1 | 42.8 | 63.3 | 72.9 | 54.4 |
| New Orleans, La. | 26 | 60.6 | 68.7 | 53.4 | 68.9 | 76.9 | 62.0 |
| New York, N. Y. | 14 | 37.4 | 45.0 | 30.7 | 49.0 | 57.3 | 41.6 |
| Philadelphia, Pa. | 16 | 39.2 | 47.1 | 32.1 | 51.2 | 60.3 | 41.6 |
| Pittsburg, Pa. | 13 | 39.5 | 48.1 | 30.5 | 52.3 | 60.7 | 42.6 |
| Portland, Oreg. | 21 | 44.9 | 52.8 | 38.5 | 48.9 | 57.3 | 42.0 |
| St. Louis, Mo. | 20 | 43.4 | 51.9 | 35.5 | 57.2 | 65.8 | 48.9 |
| St. Paul, Minn. | 4 | 27.9 | 35.8 | 19.1 | 46.1 | 55.0 | 37.2 |
| Salt Lake City, Utah. | 17 | 40.6 | 48.9 | 32.2 | 49.2 | 58.4 | 38.5 |
| San Diego, Cal. | 24 | 55.1 | 62.3 | 47.7 | 57.6 | 65.2 | 49.8 |
| San Francisco, Cal. | 23 | 51.7 | 58.4 | 46.9 | 52.8 | 60.2 | 47.4 |
| Santa Fe., N. Mex. | 11 | 37.2 | 47.5 | 27.9 | 48.0 | 59.6 | 36.0 |
| Savannah, Ga. | 25 | 57.7 | 67.0 | 49.5 | 65.5 | 75.4 | 57.2 |
| Washington, D. C. | 19 | 41.3 | 49.7 | 33.4 | 53.5 | 62.7 | 44.3 |

1) The numbers, appended to the alphabetically listed stations, are arranged with reference to their position in a scale from the lowest to the highest monthly mean minima.

Average Temperatures (F.) 1891—1895.

| Stations. | Order following the Mean Temperature. | May. Mean. | May. Mean Maximum. | May. Mean Minimum. | June. Mean. | June. Mean Maximum. | June. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 4 | 52.9 | 64.1 | 40.8 | 63.2 | 73.5 | 51.9 |
| Boston, Mass. | 10 | 56.3 | 65.5 | 48.8 | 66.4 | 74.9 | 59.0 |
| Buffalo, N. Y. | 5 | 54.0 | 61.4 | 45.6 | 67.1 | 74.3 | 59.2 |
| Chicago, Ill. | 6 | 54.7 | 62.2 | 47.2 | 67.6 | 75.4 | 60.4 |
| Cincinnati, Ohio | 20 | 62.2 | 70.8 | 53.1 | 74.7 | 83.9 | 65.5 |
| Cleveland, Ohio | 13 | 56.6 | 64.6 | 48.2 | 69.4 | 77.6 | 61.4 |
| Detroit, Mich. | 9 | 56.2 | 65.4 | 47.4 | 69.6 | 79.2 | 60.6 |
| Dodge City, Kans. | 19 | 62.0 | 74.4 | 49.4 | 72.0 | 84.5 | 59.4 |
| Eastport, Me. | 1 | 47.1 | 54.7 | 40.8 | 54.1 | 62.8 | 47.4 |
| Galveston, Texas | 27 | 74.8 | 79.1 | 71.0 | 79.9 | 84.3 | 76.1 |
| Havre, Mont. | 3 | 52.6 | 65.4 | 39.8 | 59.8 | 72.2 | 47.4 |
| Kansas City, Mo. | 21 | 62.6 | 71.9 | 53.0 | 73.4 | 82.4 | 64.1 |
| Key West, Fla. | 28 | 78.5 | 82.8 | 74.3 | 81.1 | 85.6 | 76.4 |
| Marquette, Mich. | 2 | 47.9 | 56.2 | 39.9 | 61.6 | 70.2 | 51.6 |
| Memphis, Tenn. | 24 | 68.4 | 77.9 | 59.6 | 77.7 | 87.8 | 68.6 |
| New Orleans, La. | 26 | 74.3 | 82.1 | 69.0 | 79.1 | 87.0 | 72.4 |
| New York, N. Y. | 15 | 59.1 | 68.0 | 51.5 | 59.7 | 78.4 | 52.2 |
| Philadelphia, Pa. | 17 | 61.2 | 71.1 | 52.9 | 72.1 | 80.4 | 64.0 |
| Pittsburg, Pa. | 18 | 61.3 | 70.9 | 50.9 | 72.9 | 82.9 | 63.1 |
| Portland, Oreg. | 11 | 56.3 | 66.1 | 47.8 | 59.5 | 69.1 | 51.3 |
| St. Louis, Mo. | 23 | 64.4 | 73.3 | 55.8 | 76.5 | 85.5 | 67.7 |
| St. Paul, Minn. | 12 | 56.3 | 65.6 | 46.1 | 68.2 | 77.4 | 59.1 |
| Salt Lake City, Utah. | 14 | 58.8 | 68.4 | 47.4 | 65.7 | 76.3 | 52.6 |
| San Diego, Cal. | 16 | 60.7 | 66.5 | 54.5 | 62.8 | 68.7 | 56.7 |
| San Francisco, Cal. | 8 | 55.6 | 62.5 | 50.4 | 56.3 | 64.4 | 50.8 |
| Santa Fe., N. Mex. | 7 | 55.4 | 66.9 | 43.8 | 65.2 | 76.6 | 52.9 |
| Savannah, Ga. | 25 | 71.4 | 81.0 | 63.2 | 77.6 | 87.0 | 70.1 |
| Washington, D. C. | 22 | 62.8 | 72.8 | 53.3 | 73.2 | 83.4 | 64.0 |

Average Temperatures (F.) 1891—1895.

| Stations. | Order following the Mean Maximum[1]. | July. Mean. | July. Mean Maximum. | July. Mean Minimum. | August. Mean. | August. Mean Maximum. | August. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 13 | 69.5 | 81.9 | 56.3 | 68.6 | 82.9 | 54.1 |
| Boston, Mass. | 9 | 70.6 | 79.5 | 63.1 | 69.2 | 77.1 | 62.4 |
| Buffalo, N. Y. | 5 | 69.4 | 76.2 | 61.4 | 69.1 | 76.4 | 60.7 |
| Chicago, Ill. | 7 | 71.1 | 78.0 | 64.3 | 70.8 | 76.8 | 64.4 |
| Cincinnati, Ohio | 20 | 76.0 | 85.2 | 66.1 | 75.5 | 84.8 | 65.7 |
| Cleveland, Ohio | 8 | 71.1 | 70.1 | 62.4 | 69.9 | 77.6 | 61.8 |
| Detroit, Mich. | 11 | 71.2 | 80.9 | 61.7 | 70.1 | 79.3 | 61.0 |
| Dodge, City, Kans. | 27 | 76.4 | 88.7 | 64.4 | 74.9 | 87.9 | 62.3 |
| Eastport, Me. | 2 | 59.5 | 68.9 | 51.7 | 60.2 | 68.7 | 53.7 |
| Galveston, Texas | 22 | 82.5 | 86.9 | 78.4 | 81.7 | 86.5 | 77.4 |
| Havre, Mont. | 15 | 68.1 | 82.7 | 52.2 | 66.9 | 80.8 | 50.0 |
| Kansas City, Mo. | 18 | 75.7 | 84.4 | 66.3 | 75.3 | 85.2 | 65.5 |
| Key West, Fla. | 25 | 83.1 | 87.9 | 78.2 | 83.5 | 88.2 | 78.2 |
| Marquette, Mich. | 4 | 66.1 | 73.6 | 56.2 | 63.4 | 71.1 | 55.2 |
| Memphis, Tenn. | 24 | 78.2 | 87.6 | 70.2 | 77.9 | 87.6 | 69.6 |
| New Orleans, La. | 26 | 80.2 | 87.9 | 74.2 | 80.3 | 88.2 | 74.5 |
| New York, N. Y. | 12 | 73.0 | 81.6 | 65.3 | 73.1 | 81.4 | 66.0 |
| Philadelphia, Pa. | 17 | 74.3 | 84.0 | 66.4 | 74.1 | 83.8 | 66.6 |
| Pittsburg, Pa. | 16 | 73.2 | 83.1 | 62.9 | 73.1 | 83.3 | 62.6 |
| Portland, Oreg. | 6 | 65.6 | 77.0 | 55.3 | 67.2 | 79.1 | 55.9 |
| St. Louis, Mo. | 21 | 77.3 | 86.1 | 69.0 | 76.9 | 86.0 | 68.1 |
| St. Paul, Minn. | 14 | 71.7 | 81.9 | 60.6 | 69.6 | 80.5 | 58.6 |
| Salt Lake City, Utah. | 23 | 75.5 | 87.0 | 61.4 | 75.8 | 87.7 | 61.6 |
| San Diego, Cal. | 3 | 66.2 | 71.9 | 60.7 | 68.6 | 74.4 | 63.3 |
| San Francisco, Cal. | 1 | 56.5 | 63.9 | 51.7 | 57.6 | 65.1 | 53.0 |
| Santa Fe., N. Mex. | 10 | 68.0 | 79.7 | 57.3 | 66.0 | 77.2 | 56.0 |
| Savannah, Ga. | 28 | 79.3 | 89.3 | 72.1 | 79.6 | 89.2 | 72.5 |
| Washington, D. C. | 19 | 74.5 | 84.7 | 65.5 | 74.7 | 84.8 | 65.8 |

[1]) The numbers in the first column are arranged in a scale from 63.9°, the lowest mean maximum to 89.3°, the highest, so that the position of each station is displayed with reference to the greatest heat of the United States in these two months.

Average Temperatures (F.) 1891—1895.

| Stations. | Order following the Mean Temperature[1]. | September. Mean. | September. Mean Maximum. | September. Mean Minimum. | October. Mean. | October. Mean Maximum. | October. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 5 | 50.7 | 73.5 | 46.1 | 44.3 | 57.4 | 32.8 |
| Boston, Mass. | 8 | 63.5 | 71.7 | 56.2 | 52.2 | 59.8 | 45.3 |
| Buffalo, N. Y. | 10 | 64.3 | 71.2 | 56.0 | 51.8 | 57.6 | 43.8 |
| Chicago, Ill. | 14 | 66.5 | 73.6 | 59.1 | 51.6 | 58.8 | 44.0 |
| Cincinnati, Ohio | 21 | 70.6 | 80.2 | 60.6 | 55.5 | 64.8 | 45.4 |
| Cleveland, Ohio | 13 | 65.9 | 73.9 | 57.8 | 52.1 | 59.4 | 44.2 |
| Detroit, Mich. | 12 | 65.0 | 74.1 | 56.2 | 50.3 | 58.0 | 42.8 |
| Dodge City, Kans. | 20 | 69.8 | 83.2 | 56.9 | 55.4 | 70.1 | 42.1 |
| Eastport, Me. | 2 | 55.8 | 63.2 | 50.0 | 47.0 | 52.4 | 41.7 |
| Galveston, Texas | 27 | 70.9 | 84.2 | 75.6 | 72.2 | 77.1 | 67.5 |
| Havre, Mont. | 1 | 55.3 | 69.0 | 41.3 | 44.3 | 58.0 | 31.3 |
| Kansas City, Mo. | 22 | 70.8 | 81.4 | 60.7 | 57.2 | 67.9 | 46.9 |
| Key West, Fla. | 28 | 82.3 | 86.9 | 76.5 | 77.9 | 81.4 | 74.1 |
| Marquette, Mich. | 3 | 59.0 | 68.4 | 51.5 | 45.7 | 52.2 | 39.5 |
| Memphis, Tenn. | 24 | 73.7 | 84.4 | 64.6 | 61.4 | 72.5 | 51.1 |
| New Orleans, La. | 26 | 78.3 | 86.1 | 72.3 | 68.8 | 77.5 | 61.6 |
| New York, N. Y. | 16 | 67.5 | 75.4 | 60.5 | 54.6 | 62.3 | 47.0 |
| Philadelphia, Pa. | 17 | 68.3 | 77.7 | 60.9 | 55.2 | 63.8 | 47.8 |
| Pittsburg, Pa. | 18 | 68.5 | 78.2 | 58.9 | 54.0 | 63.4 | 44.2 |
| Portland, Oreg. | 4 | 59.1 | 68.4 | 51.2 | 52.7 | 61.6 | 45.0 |
| St. Louis, Mo. | 23 | 72.0 | 81.7 | 63.0 | 57.5 | 67.3 | 48.5 |
| St. Paul, Minn. | 9 | 63.5 | 74.7 | 52.9 | 47.9 | 57.7 | 38.7 |
| Salt Lake City, Utah | 11 | 64.0 | 76.3 | 52.6 | 53.2 | 63.8 | 42.0 |
| San Diego, Cal. | 15 | 66.7 | 73.4 | 60.0 | 63.2 | 70.7 | 55.8 |
| San Francisco, Cal. | 6 | 59.7 | 67.5 | 54.6 | 57.4 | 65.6 | 52.4 |
| Santa Fe., N. Mex. | 7 | 61.6 | 72.8 | 50.8 | 49.9 | 61.1 | 39.4 |
| Savannah, Ga. | 25 | 76.0 | 84.5 | 69.3 | 66.0 | 75.5 | 57.5 |
| Washington, D. C. | 19 | 68.7 | 78.7 | 59.8 | 54.7 | 65.0 | 45.5 |

Average Temperatures (F.) 1891—1895.

| Stations. | Order following the Mean Minimum. | November. Mean. | November. Mean Maximum. | November. Mean Minimum. | December. Mean. | December. Mean Maximum. | December. Mean Minimum. |
|---|---|---|---|---|---|---|---|
| Bismarck, N. Dak. | 1 | 24.4 | 34.8 | 15.2 | 15.8 | 25.1 | 6.6 |
| Boston, Mass. | 13 | 41.6 | 48.3 | 35.0 | 33.7 | 40.6 | 26.8 |
| Buffalo, N. Y. | 11 | 38.8 | 44.1 | 32.8 | 32.4 | 37.0 | 26.0 |
| Chicago, Ill. | 9 | 35.4 | 41.0 | 29.1 | 29.6 | 35.1 | 23.4 |
| Cincinnati, Ohio | 18 | 42.2 | 49.4 | 34.8 | 37.4 | 43.5 | 30.4 |
| Cleveland, Ohio | 14 | 39.2 | 45.4 | 33.1 | 33.3 | 39.0 | 27.3 |
| Detroit, Mich. | 10 | 36.7 | 42.0 | 31.3 | 30.6 | 35.7 | 25.1 |
| Dodge City, Kans. | 7 | 40.8 | 54.9 | 28.9 | 32.5 | 45.1 | 22.8 |
| Eastport, Me. | 6 | 38.1 | 43.0 | 32.6 | 28.0 | 33.2 | 21.3 |
| Galveston, Texas | 27 | 63.4 | 68.3 | 58.3 | 57.9 | 62.5 | 52.6 |
| Havre, Mont. | 2 | 28.7 | 37.8 | 18.4 | 21.9 | 28.5 | 10.8 |
| Kansas City, Mo. | 12 | 40.8 | 49.2 | 32.3 | 34.4 | 42.4 | 26.7 |
| Key West, Fla. | 28 | 73.7 | 77.2 | 70.0 | 70.5 | 74.1 | 66.7 |
| Marquette, Mich. | 4 | 30.7 | 35.7 | 24.7 | 22.4 | 29.3 | 18.4 |
| Memphis, Tenn. | 22 | 50.4 | 58.8 | 41.4 | 44.8 | 52.4 | 37.9 |
| New Orleans, La. | 26 | 50.1 | 68.4 | 52.9 | 55.8 | 64.1 | 48.6 |
| New York, N. Y. | 16 | 43.4 | 50.1 | 37.4 | 36.0 | 42.6 | 30.1 |
| Philadelphia, Pa. | 20 | 43.8 | 50.8 | 37.5 | 37.0 | 44.1 | 31.1 |
| Pittsburg, Pa. | 15 | 42.6 | 50.0 | 34.6 | 37.1 | 54.9 | 29.4 |
| Portland, Oreg. | 21 | 46.1 | 51.5 | 41.0 | 40.5 | 45.3 | 36.4 |
| St. Louis, Mo. | 19 | 42.5 | 49.8 | 35.2 | 37.6 | 44.4 | 30.8 |
| St. Paul, Minn. | 3 | 28.7 | 36.1 | 20.5 | 21.2 | 27.5 | 13.6 |
| Salt Lake City, Utah | 8 | 41.7 | 50.8 | 32.8 | 30.1 | 37.0 | 23.1 |
| San Diego, Cal. | 25 | 58.5 | 67.4 | 50.3 | 54.5 | 63.5 | 46.0 |
| San Francisco, Cal. | 24 | 56.5 | 64.0 | 50.6 | 50.3 | 54.9 | 45.7 |
| Santa Fe., N. Mex. | 5 | 38.6 | 49.5 | 28.9 | 28.9 | 38.0 | 21.0 |
| Savannah, Ga. | 23 | 57.0 | 66.1 | 48.4 | 53.1 | 62.8 | 44.3 |
| Washington, D. C. | 17 | 44.2 | 52.4 | 36.2 | 37.8 | 46.2 | 30.1 |

[1]) For the spring and autumn months, the mean temperature has the most distinctive value, wherefore, the stations are arranged in sequence accordingly.

*Moisture in the Air.* In January, the least moisture (0,5 grain per cubic foot) is found in the extreme northwest; this increases quite regularly to 4 gr. on the Gulf, 6.5 gr. at Key West, nearly 3 gr. on the Pacific, 2.1 gr. at Yuma, 1.3 gr. at Chicago, 1.6 gr. at New York City and 1.7 gr. at Washington. In July, the northwest has 5.5 gr. per cubic foot, increasing to 9 gr. on the Gulf coast. The lowest, 1.5 gr. is found at Winnemucca. All through the region from the Rockies westward, except on the Pacific coast the air is very dry, hardly reaching 3 gr. per cubic foot. Chicago has 5.7 gr.; New York City, 6.7 gr.; Washington 7.0 gr.; and Key West, 9.1 gr. Corpus Christi has 9.5 gr. the largest in the country.

*Precipitation.* The annual precipitation, unlike the temperature varies in an east and west direction more than from north to south. The Atlantic coast receives over 40 inches in the north and over 50 inches in the south. The lake regions have from 33 in. to 49 in., the Gulf coast has about 60 in., but this diminishes toward the south. The extreme point of Texas has but 32 in., and Key West 41 in., while the Dry Tortugas in the Gulf have even less. The upper Missouri has about 15 in., as also the north and the middle Rocky Mountain region. Yuma has 3 in.; San Diego, 10 in.; San Francisco, 23 in.; Portland, Oregon, 50 in. and the rainiest part of the whole country in northwestern Oregon.

*Least Rainfall.* The least rainfall in the United States is found in the west and southwest. The limit of least rainfall for the purpose of this discussion will be taken at 1 inch per month. The area of least rainfall, as defined above, is smallest in April. At this time it occupies New Mexico, the most of Utah and Nevada and parts of the adjoining states. By May, the western boundary of this area has traveled westward and strikes the Pacific coast, and progresses northward until in August, it leaves the coast and the line crosses the area of the United States approximately from north to south. Meantime the heavier rainfall has begun in the extreme northwest, and a western boundary of the area appears in this month for the first time. The area in August, therefore, is bounded on the east by a line which is, approximately, the meridian of 115°. It is bounded on the west by a line which crosses the extreme northwestern angle of the United States. With the succeeding months, this band travels gradually eastward and reaches its extreme eastern position in the winter months. With the beginning of spring, the area travels rapidly westward, and by April it has taken up the position with which we began. The area of least rainfall is not confined to the United States. It extends to the southward over Mexico, and this extension continues during the whole year. There is an extension northward which begins in July and lasts until March. In the period of greatest extension in the United States, namely, in winter, the band extends northward and slightly eastward, and probably occupies the plains to the north of us, finally joining the Arctic area of least rainfall.

*Greatest Rainfall.* Six inches of rain per month is taken in this discussion as a maximum. It appears that there are six different regions where

the rainfall is, in some months, above 6 inches. The first is in the extreme northwest. It begins at Tatoosh Island, Washington in October. It gradually increases and reaches its greatest extent in December. At this time the line of six inches of rainfall, entering the United States on the north, south of Vancouver Island, extends down along Puget Sound; thence southward to Mount Rainier; thence eastward along the Columbia River up to the Cascade Mountains and back to the Willamette: thence south, not far from the coast, disappearing on the coast not far to the north of San Francisco, California. The highest monthly rainfall at this time is 14.5 inches in the vicinity of Tatoosh Island, Washington. There is a small outlier in the Sierra Nevada Mountains. The second area is a very variable one in Alabama and Mississippi and extending to some extent into adjoining states. It begins in January and continues until March. The highest rainfall is 9 inches in March. Within it is small area of unusually high rainfall at the southern extremity of the Appalachian range, with an annual precipitation of over 76 inches. The third area is one in northeastern Texas extending slightly into Indian Territory. It is found there in April and May, the highest rainfall being 9 inches. The fourth area is a small patch to be found in northern Missouri in May and June, the highest rainfall here being 9 inches. The fifth area beginning properly in March and continuing to October, starts at Cape Hatteras, extends gradually inward, never reaching far from the coast, and attains its extreme limit in July and August. At this time, it covers extreme southeastern Virginia, the eastern third of North Carolina and a considerable part of the coast of South Carolina. The sixth area is the region of the subtropic rains in Florida. It begins in June and ends in October. Its greatest expansion is in July, and also the greatest rainfall, which amounts to about 10 inches. It extends into southern Georgia, thence westward along the Gulf coast to the middle of the coast of Louisiana.

*Topography and its effects on rainfall.* From the great plains westward the lines of equal rainfall are, approximately, north and south. They are approximately parallel with the Atlantic coast. In the lake region, while they approach parallelism to the parallels of latitude, yet there are some variations, evidently due to the effects of these great bodies of fresh water. In general, the rainfall decreases also with the elevation above sea-level. Certain peaks and mountain ranges on the other hand are outlined by the mean rainfall. This is true of the Sierra Nevadas and to a less extent in the Cascades at the Dalles, where the Columbia River breaks through. In spring, this area is distinctly outlined with a rainfall of 15 inches, while in the Willamette Valley, it is only 10 inches and immediately to the east of the mountains only about 5 inches. In winter, the whole range is outlined by the lines of greater rainfall, about 38 inches or more.

The rainfall to the leeward and windward side of mountain ranges is also marked. On the Pacific coast, where the prevailing winds are distinctly from the west, the western slopes of the Sierra Nevadas show on the annual map

a rainfall of 20 to 40 inches, while immediately to the eastward in the lee of these mountains, it is only from 2 to 6 inches.

Islands occur also in the areas of least rainfall, and are found at the sources of many of the great rivers of the west, such as the Rio Grande which flows from a rainfall island found in northern New Mexico and southern Colorado. The great swampy areas of the United States are found in regions of highest rainfall. This is true for example of the Everglades in Florida, where the rainfall is 50—70 inches (127—178 cm) per year. It is also true of the great swampy district lying on the coast of North Carolina, where the rainfall is 60 inches per year, and upward: also the swampy district about the mouth of the Mississippi River; but it is not so true of the celebrated swampy district lying to the west of the Mississippi along the Gulf coast. About the mouth of the Mississippi, the rainfall is above 60 inches (152 cm), while for the celebrated swampy district the rainfall is less than 60 inches though it is above 50 inches. This wet area has probably been but recently recovered from the Gulf by deposits brought down by the great river [1]).

The Great Lakes also influence to some extent the rainfall. In general, for instance, it will be found that the rainfall is greater on the east shore of Lake Michigan than on the west, the prevailing winds crossing the lake from the west. Much the same is true of the east shores of Lake Erie and Lake Ontario.

*Maximum monthly rainfall.* It is of special interest to see in what way the rainfall is distributed geographically over the United States with reference to the seasons. A maximum of rainfall in March extends along the Atlantic and Gulf coasts from New England to Texas and extends down into the peninsula of Florida. It spreads well into the interior and covers the region in the vicinity of the lower lakes. In April, it has passed westward and occupies, but a little territory in Arkansas and Louisiana. By May, this maximum has passed farther westward and occupies the central plains, the crest running in a curve from the vicinity of Davenport, Iowa, around the extreme north of Texas, and northward in the vicinity of Cheyenne, Wyoming.

These rains are well distributed for greatest usefulness to crops and growing plants. The regions of summer rainfall are especially interesting. There is an enormous territory in the United States over which a maximum rainfall occurs in June. The line which represents the crest of this wave begins in western Washington and extends to the southern part of peninsula Florida. There is also a distinct extension of this area eastward in the vicinity of the upper Great Lakes. This area of higher rainfall extends from the line, both toward the east and toward the west in July, occupying the remainder of the territory of the United States east of the Mississippi River, and also a territory in the southwestern plains, through Colorado, New Mexico and Arizona. It has extended still farther from the main axis in June, and is found then along

1) HARRINGTON, MARK W.: Rainfall and Snow of the United States, compiled to the End of 1891, United States Department Agriculture. Weather Bureau Bulletin C. Washington 1894.

the Atlantic coast, also along a part of the Gulf coast. It is also found in the western region before mentioned, only somewhat farther south, occupying northern Texas, New Mexico and Arizona.

The regions of maximum rainfall in autumn are not of much interest, except in the extreme southeast, where there is a marked maximum about the peninsula of Florida in September. In September, also, there is a secondary maximum in the region of the upper Great lakes, a part of the upper Mississippi Valley, and along the Texan Gulf coast from Galveston westward. In October, the maximum on the upper lakes has extended to the lower, and in November this maximum has extended to the coast of New England, and to an area through the central states, reaching from Ohio to Texas. — The regions of maximum rainfall in winter are most interesting on the Pacific coast. Here the maximum rainfall occurs in December, and this area of maximum occupies not only the entire coast, but a region in the interior which generally extends to the continental divide. Toward the south there is a secondary maximum in the eastern part of this area, and in New Mexico. In January there is a region of maximum precipitation extending from southern Iowa to Lake Huron, and another much more extensive region extending along the Atlantic and Gulf coast to the peninsula of Florida. These two waves of higher rainfall for January meet in February along a line which lies approximately half way between then.

*Minimum monthly rainfall.* Beginning with the spring minimum, we find that in March there is only one — on the lower part of the peninsula of Florida. By April, the area of minimum rainfall occupies the coast from Norfolk southward, and also the interior from Eastport, Maine, to Little Rock, Arkansas. By May, it has drifted on until it occupies the coast from Massachusetts to Norfolk, Virginia, and along the Gulf coast to New Orleans, Louisiana, and northward to Arkansas and Tennessee. The summer minima are found in June along the New England coast to Long Island. In July they are found in a larger area, extending over the lower peninsula of Michigan to central Texas. In August there is a series of minima along the lakes from Rochester to Cleveland, and an extensive area of minimum rainfall over the western states, along the Pacific coast, in the interior of Idaho and also through central Illinois. In September the minimum area extends from Rochester, New York, to Cairo, Illinois and from Portland, Maine, to Long Island. In October, the New England series of minima has passed southward and is now found in southern New York, eastern Pennsylvania, New Jersey and Maryland. It is also found over the southwestern states from Missouri southward, and from Georgia westward to Illinois, in the lower Mississippi Valley. In November the minima extend along the Atlantic coast from Delaware to Florida and cover a large area in the northwest from the Cascade Range eastward to the Missouri River and southward to the northern boundary of New Mexico and Arizona. The winter series of minima is somewhat more complicated and will be omitted from discussion here.

*Character of rainfall.* It is a matter of interest to ascertain whether the rainfall at any particular place is due largely to small rains, or to great ones. If the former is the case, it will generally be favorable to agricultural operations and not damaging to crops. Four types may be distinguished by a study of the meteorologic maps and records. The first type is that which is found on the lower lakes and which has its extreme at Oswego in New York. Its especial characteristic is the relatively large number of days on which small rains fell. This number of days is often greater than those on which no rain fell. This is particularly the case with these rains in winter, but it may extend in some cases through the year, and at Oswego it is found that this maximum appears clearly in the annual rainfall curve. The second type is best illustrated in the extreme northwest, but it is more clearly seen over our northern latitudes generally, except on the great plains, where the rainfall gradually passes into the fourth type. In the northeast, there is a combination of type two with type one, the traces of the latter decreasing as the distance from the lower lakes is increased. Type one is that of smallest rainfall, type two of small rainfalls. The third type belongs to the southeast and is best marked at New Orleans, La. It is marked by a greater number of medium rainfalls, due to the fact that the rains in our southern latitudes are largely local rains-thunderstorms, showers, etc. The rain of our northern latitudes comes usually in connection with general storms; the rain of the southern latitudes with local storms. Medium rains of short duration are, therefore, more frequent in the southern states. The fourth type is that of little rain. It is found in the drier regions of the United States, and is best marked at Yuma, Arizona. There is little rain of any sort and this usually comes with small showers, but cloudbursts occasionally occur. The rains of this type are generally local.

*Clouds.* The average cloudiness is about 55 per cent. over the country in January, with over 70 per cent. in the north Pacific states, 25 to 35 per cent. in the south Pacific states, 40 per cent. in the south plateau region, 45 per cent. in the Missouri Valley, and 70 per cent. in the lower lakes. In July, there is a diminished cloudiness, about 45 per cent., with 40 to 50 per cent. on the Pacific coast, 15 to 25 per cent. in the interior near the Pacific, and 45 to 50 per cent. on the Atlantic coast. The diurnal range of clouds over the whole country shows a minimum about midnight and a maximum at 2 to 3 p. m.

## 3. Mexico.

*Zones.* — Although Mexico is intersected by the Tropic of Cancer, yet its geographic position gives it a great diversity of climate determined far more by altitude than its distance from the North Pole or the Equator. The heat of the torrid zone is experienced on the seacoast and the low, marshy tracts bordering on the Gulf of Mexico, and in the enclosed valleys 3,000 feet above sea level. Thus the City of Mexico in latitude 19° 31′ N. at an elevation of 7,340 feet enjoys a much more general climate than New York, or Chicago. The night breezes temper the heat of the day and the rains which begin

*usually in June and last until November, are so abundant and fall so regularly,* especially in the afternoon, that they refresh the atmosphere. So decided is the effect of the rains on the atmosphere that the seasons are divided into two only, viz., the dry and the rainy season, which are independent of the elevation upon which the classification into three superimposed zones depends. These may be conveniently tabulated as follows:

| | | | | |
|---|---|---|---|---|
| Hot Zone . . . . | (Tierra Caliente) . | 0 to 3,000 ft. | 77°—82° F. | (25°—27.8° C.) |
| Temperate Zone | (Tierra Templada) | 3,000 to 5,000 ft. | 62°—70° F. | (16.7°—21.1° C.) |
| Cold Zone . . . | (Tierra Fria) . . . | 7,000 to 10,000 ft. | 58°—64° F. | (14.4°—17.8° C.) |
| Boreal Zone. . . | ( » ) . . . | 10,000 to 18,000 ft. | — | |

The mean temperature in the hot regions varies from 77° to 82° F. (25°—27.8° C.), *and often rises to* 100° F. (37.8° C.), *and in some coast loca*lities to 105° F. (40.5° C.). Yet even here the atmosphere is constantly refreshed by the night breezes, and in summer by the rains which prevail from June to November and fall regularly and at fixed intervals from about one to three hours daily.

The temperate zone has a *mean* temperature of from 62° to 70° F. (16.7°—21.1° C.), the variation during the season being not more than 4° to 5° F. and it may, therefore, be called the region of eternal spring. It is somewhat comparable to that of Mediterranean lands. As in Algeria and Italy, the orange, fig and olive thrive amid wheat and maize fields. The tierra templada comprises all the higher mountain terraces and parts of the plateau itself. The Sierras rise high enough to condense some of the moisture derived from the neighboring seas and this condensed moisture falls as rain during the invierno, that is, the wet summer months. The dry season verano, later follows.

Between 7,000 feet above the level of the sea and greater heights lies the cold region having a main temperature of from 58° to 64° F. (14.4°—17.8° C.). Here the rainfall is five times less than in the temperate zone. The changes of temperature are but small from one end of the year to the other, although the diurnal changes between sunrise and sunset are often considerable. The higher mountains, Orizaba, Popocatepetl, Ixtaccihuatl are covered with snow and the conditions on these peaks above the limit of vegetation are more extreme and arctic.

*Tables.* The following tables will present the meteorologic conditions in Mexico as they have been reported from a number of stations in various parts of the Republic. See pag. 150—151.

*Climate of the City of Mexico.* By way of specifically illustrating the climate of Mexico, that of the City of Mexico, as deduced from data provided by Mariano Barcena[1]), will be given as a sample. The mean monthly temperature varies from 53.6° F. (12° C.) in December to 64.4° F. (18° C.) in

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1) Report of the international meteorological Congress held at Chicago, August 21—24, 1893. Bulletin II. Part 3. Weather Bureau United States Department Agriculture. Washington 1896.

## Mexican Climatologic Data[1]).

By Señor MANUEL E. PASTRANA, Director of the Central Meteorologic-Magnetic Observatory.

1903.

| January. Stations. | Altitude. | Temperature. Max. | Min. | Mean. | Relative humidity. Jan. | Febr. | March. | Precipitation. Jan. | Febr. | March. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *°F.* | *°F.* | *°F.* | % | % | % | *Ins.* | *Ins.* | *Ins.* |
| Chihuahua | 4,684 | 75.2 | 29.3 | 56.8 | 50 | 34 | 36 | 0.18 | T. | T. |
| Guadalajara | 5,186 | 84.2 | 39.2 | 56.8 | 63 | 54 | 50 | 5.20 | 0.37 | 0.35 |
| Guanajuato | 6,640 | 77.0 | 38.1 | 54.0 | 60 | .... | .... | 2.46 | ..... | .... |
| Leon (Guanajuato) | 5,906 | 74.1 | 33.4 | 52.9 | 64 | 58 | 49 | 2.14 | 0.03 | 0.49 |
| Mazatlan | 25 | 81.7 | 56.7 | 70.0 | 65 | .... | 72 | 1.37 | ..... | .... |
| Merida (February) | 50 | 96.8 | 53.1 | 77.7 | .... | 68 | .... | ..... | 0.47 | .... |
| Mexico (Obs. Cent.) | 7,472 | 71.1 | 39.2 | 54.5 | 50 | 49 | 44 | T. | 0.82 | 0.02 |
| Monterey | 1,626 | 79.9 | 36.1 | 56.1 | 68 | 69 | .... | 1.21 | 0.17 | .... |
| Morelia (Seminario) | 6,401 | 73.4 | 38.8 | 54.0 | 68 | 61 | 61 | 2.27 | 0.03 | .... |
| Pachuca | ..... | ..... | ..... | ..... | .... | .... | 66 | ..... | ..... | 0.69 |
| Puebla (Col. Cath.) | 7,108 | 72.9 | 40.6 | 56.5 | 57 | 59 | .... | ..... | 0.03 | .... |
| Puebla (Col. d Est.) | 7,118 | 73.9 | 35.6 | 54.0 | 58 | 58 | 51 | ..... | T. | 0.52 |
| Queretaro | 6,070 | 70.7 | 39.2 | 54.9 | 52 | 50 | .... | 0.87 | 0.11 | .... |
| Zacatecas | 8,015 | 75.4 | 26.2 | 46.4 | 58 | 63 | 43 | 1.48 | T. | 0.04 |
| Zapotlan | 5,078 | 77.5 | 40.6 | 58.1 | 66 | 62 | 49 | 6.13 | 0.42 | .... |

| April. Stations. | Altitude. | Temperature. Max. | Min. | Mean. | Relative humidity. April. | May. | June. | Precipitation. April. | May. | June. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | *°F.* | *°F.* | *°F.* | % | % | % | *Ins.* | *Ins.* | *Ins.* |
| Chihuahua | 4,684 | 89.6 | 42.8 | 70.9 | 34 | 26 | 44 | T. | 0.32 | 3.34 |
| Guadalajara | 5,186 | 89.6 | 47.3 | 72.3 | 41 | 43 | 61 | T. | 0.11 | 6.95 |
| Guanajuato | 6,640 | 93.4 | 51.4 | 71.6 | 35 | .... | .... | T. | ..... | .... |
| Leon (Guanajuato) | 5,906 | 90.0 | 51.8 | 71.4 | 40 | 43 | 56 | 0.34 | 0.55 | 3.00 |
| Mazatlan | 25 | 84.6 | 64.8 | 74.3 | 77 | 75 | 78 | ..... | ..... | 3.38 |
| Merida | 50 | ..... | ..... | ..... | .... | .... | .... | ..... | ..... | .... |
| Mexico (Obs. Cent.) | 7,472 | 85.1 | 46.4 | 65.5 | 44 | 49 | 67 | 0.42 | 0.47 | 7.59 |
| Morelia (Seminario) | 6,401 | 83.3 | 48.2 | 65.5 | 51 | 51 | 77 | 0.42 | 0.53 | 3.81 |
| Puebla (Col. Cath.) | 7,108 | 86.7 | 44.1 | 65.3 | 58 | 59 | .... | 1.84 | 0.88 | .... |
| Puebla (Col. d. Est.) | 7,118 | 85.3 | 40.8 | 64.0 | 50 | 56 | 72 | 1.46 | 0.53 | 6.74 |
| Toluca | 8,812 | 79.7 | 40.6 | 59.0 | 45 | .... | .... | 0.69 | ..... | .... |
| Zacatecas (June) | 8,015 | 82.8 | 42.3 | 63.5 | .... | .... | 58 | ..... | ..... | 1.57 |
| Zapotlan | 5,078 | 92.1 | 53.2 | 71.6 | 49 | 46 | 66 | T. | T. | 2.87 |

[1]) The temperature can be judged sufficiently by incorporation of the records for the months of January, April, July and October. Relative humidity and precipitation is given for all the months of the year. The letter T indicates a "trace".

| July. Stations. | Altitude. | Temperature. Max. | Min. | Mean. | Relative humidity. July. | Aug. | Septbr. | Precipitation Ins. July. | Aug. | Septbr. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | °*F.* | °*F.* | °*F.* | % | % | % | *Ins.* | *Ins.* | *Ins.* |
| Chihuahua | 4,684 | 95.0 | 66.2 | 80.6 | 38 | 46 | 47 | 0.97 | 5.33 | 3.71 |
| Guadalajara | 5,186 | 86.0 | 53.6 | 70.9 | 73 | 78 | 77 | 10.45 | 10.05 | 5.47 |
| Leon (Guanajuato) | 5,906 | 85.6 | 55.6 | 69.4 | 64 | 77 | 70 | 5.89 | 7.62 | 3.38 |
| Mazatlan | 25 | 91.9 | 75.2 | 82.4 | 76 | 78 | 77 | 2.74 | 11.25 | 8.40 |
| Merida (August) | 50 | 96.1 | 64.0 | 80.6 | ... | 74 | 74 | ..... | ..... | 1.29 |
| Mexico (Obs. Cent.) | 7,472 | 77.4 | 52.2 | 62.2 | 70 | 73 | 71 | 5.32 | 4.41 | 2.00 |
| Morelia (Seminario) | 6,401 | 77.9 | 53.6 | 62.6 | 79 | 79 | 79 | 6.94 | 4.11 | 3.27 |
| Pachuca | 7,959 | ..... | ..... | ..... | .... | .... | .... | ..... | ..... | ..... |
| Puebla (Col. Cath.) | 7,108 | 75.6 | 49.3 | 61.0 | 78 | 81 | 82 | 9.80 | 5.31 | 5.82 |
| Puebla (Col. d Est.) | 7,118 | 75.4 | 46.4 | 62.1 | 75 | 76 | 77 | 5.67 | 6.69 | 5.93 |
| Toluca | 8,812 | 76.1 | 46.4 | 57.2 | 76 | .... | .... | 6.53 | ..... | ..... |
| Zacatecas | 8,015 | 79.2 | 45.5 | 61.2 | 69 | 74 | 70 | 1.99 | 4.63 | 2.16 |
| Zapotlan | 5,078 | ..... | ..... | ..... | .... | .... | 76 | ..... | ..... | 6.50 |

| October. Stations. | Altitude. | Temperature. Max. | Min. | Mean. | Relative humidity. Octbr. | Nov. | Dec. | Precipitation Ins. Octbr. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | °*F.* | °*F.* | °*F.* | % | % | % | *Ins.* | *Ins.* | *Ins.* |
| Chihuahua | 4,684 | 84.2 | 46.4 | 66.0 | 39 | .... | 28 | 0.97 | ..... | 0.20 |
| Guadalajara | 5,186 | 80.6 | 50.0 | 66.6 | 71 | 61 | 61 | 3.21 | 0.00 | 0.00 |
| Guanajuato | 6,640 | 84.0 | 45.3 | 63.0 | 61 | .... | 50 | 1.55 | ..... | 0.00 |
| Leon (Guanajuato) | 5,906 | 80.8 | 41.9 | 62.4 | 68 | 56 | 57 | 1.61 | T. | T. |
| Mazatlan | 25 | 90.1 | 68.9 | 81.1 | 74 | 75 | 72 | 0.70 | 0.00 | T. |
| Merida | 50 | 95.0 | 57.9 | 79.0 | 79 | .... | 71 | 1.06 | ..... | 0.11 |
| Mexico (Obs. Cent.) | 7,472 | 74.8 | 41.0 | 58.1 | 70 | 55 | 54 | 1.89 | 0.04 | T. |
| Morelia (Seminario) | 6,401 | 72.7 | 44.6 | 58.3 | 74 | .... | 58 | 2.69 | ..... | 0.00 |
| Parral | ..... | ..... | ..... | ..... | .... | .... | .... | ..... | ..... | 0.04 |
| Puebla (Col. Cath.) | 7,108 | 77.4 | 42.3 | 57.9 | 77 | 65 | 68 | 4.12 | 0.41 | T. |
| Puebla (Col. d. Est.) | 7,118 | 75.2 | 41.9 | 58.5 | 74 | 60 | 63 | 4.35 | 0.17 | 0.01 |
| Zacatecas | 8,015 | 77.0 | 37.9 | 55.8 | 64 | 53 | 49 | 2.89 | 0.07 | 0.00 |
| Zapotlan | 5,078 | 81.1 | 46.4 | 66.9 | 70 | .... | .... | 2.53 | ..... | ..... |

May. It rises from the beginning of the year to the fifth month, falls in the following one, and remains with small variation during the rainy season; it falls in the autumn and continues its descent until the winter. The absolute maximum temperature under shelter, that is to say, in the shade and freely exposed to the wind, vary from 73.4° F. (23° C.) to 88.8° F. (31.6° C.) and the corresponding limits in the open air are 99.8° F. (37.7° C.) and 120.5° F. (49.2° C.); the first have their maxima in April and the last in September. The absolute minima under shelter ranged from 29° F. (— 1.7° C.) to 17.3° F. (— 8.2° C.) and in the open air 19.1° F. (— 7.2° C.) to 25° F. (— 3.9° C.).

The greatest falls of temperature have occurred in December in both cases, and these great descents have been rare in the sixteen years compared. The distribution of heat in the winter, as well as in other seasons, is varied. Consequently the inconveniences caused by the extreme limits are not prolonged for many hours; in general, the temperature in winter is mild from eleven o'clock a. m. to five o'clock p. m., and in the other seasons the mornings and nights are always cool.

The principal elements which modify the normal course of the temperature are the winds, the clouds, and the rains. The winds from the two southern quadrants increase the heat and dry the air; the currents from the north cool and moisten it. Generally the winds from the winds from the first quadrant clear up the clouds suddenly and induce a decided lowering of the temperature. A sky entirely covered with clouds keeps the temperature high, while the passage of loose clouds at the hours of maximum temperatures impedes its rise. The hottest month is April; the coolest, December.

The course of the mean monthly temperature of the ground at the depth of 0.85 (33.75 inches) meter varied from 56° F. (13.3° C.) to 63.5° F. (17.5° C.) rising from the first to the sixth month of the year and falling from June to December. The lowest reading corresponds to January and the highest to the month of June, and the regularity of its course indicates that it is free from external influences. The annual mean of 60° F. (15.6° C.) differs only two-tenths of a degree at most from the mean of the surrounding air.

Rain occurs generally in all months of the year, although in no regular manner in the spring. The rainy season so called, can be said to begin in May, to be fully established in June, and to end in October, August being the most rainy and most stormy month. The mean quantity of water which has collected in this latter month amounted to 129.8 mm., and the greatest depth of rain corresponding to any one day in the same month amounted to 63.5. The mean annual depth of rainfall in sixteen years is found to be 593.5 mm., and the mean of the ten years from 1880—1890 is 614.5. The greatest annual depth registered in sixteen years amounted to 892.6 mm., and the minimum to 444.2. Generally, the greatest quantity of water falls on the mountains of the Valley of Mexico, whither the clouds are driven by the winds.

The cloudiness in Mexico increases in the summer months, there being in the other seasons a great number of entirely cloudless days, with a clear sky of beautiful blue. Cirrus veils are precursors of storms and last but a few days. Haze on the horizon is prevalent in some of the spring months, but it disappears in the rainy season, during which the atmosphere becomes notably transparent, the twilight lasting remarkably and presenting brilliant displays at sunrise and sunset. The prevailing direction of the clouds is from the southwest, but in the rainy season they proceed from the first quadrant.

The dominant wind in the City of Mexico is the northwest, which prevails the greater part of the year, especially in autumn and winter. It is the

dampest and coldest wind, and the one which increases the barometric pressure. The mean annual wind velocity is 0.8 meters per second, and on studying the monthly means it is observed that in the majority of the months it is about one meter. The greatest velocity registered in sixteen years 21 meters per second, in a wind blowing from the northeast. Generally in the spring there are wind squalls every afternoon, but the greatest velocities are observed in the summer just before the storms. As a rule, every night, although for a few hours only, there occur gusts of north winds, which usually simply cool the air, but sometimes they cause disagreeable and even unhealthy weather.

## 4. Central America.

In order to present a synopsis of the climate of Central America that of the three republics of Guatemala, Nicaragua and Costa Rica is given.

### a. Guatemala.

The people of Guatemala distinguish three zones, called as in Mexico *tierra caliente, tierra templada* and *tierra fria* and two seasons, the moist, or humid (invierno) and a dry one (verano), or summer. The tierra caliente comprises the coast lands of the Atlantic and Pacific oceans. The tierra templada, or temperate zone is found on the highlands or "mesetas centrales" from 2000 to 5000 feet above the sea level. The tierra fria, or cold zone, is situated above the elevation of 5000 feet, especially in the departments of Sololá, Totonicapam, Quiché; Huehuetenango, Quezaltenango and San Marcos regions known as Los Altos. The rainy season begins in May and lasts until October in the interior, and until December along the coasts. The hottest months are March and April, the coolest December and January.

Going more into details, Guatemala lies entirely in the Torrid Zone. Stretched out between two oceans not far from each other, the climate would be uniformly hot and moist, but for her varied mountains, especially the Cordilleras de las Andes which oppose themselves to the prevailing winds, causing notable differences, not only in temperature, but also in rainfall, humidity of the air, clouds and other meteorologic phenomena. The predominant winds are from the east and north. Only along the Pacific coast and on the southern slopes of the southern Cordilleras are southern and southwestern winds frequent at certain times of the year. As the sun passes twice a year to the zenith of each locality, so the temperature is higher at those times (April, May and August) than in the intermediary periods (July, December and January). The daily course of temperature is generally simple, although clouds and winds cause irregularities. The minimum is observed at sunrise and the maximum between two and three o'clock in the afternoon. CARL SAPPER gives the following table of average centigrade temperatures.

The atmospheric humidity is high all over the country, except in the dry regions situated between humid or moist mountains, as at Salamá and in

| Temperature in C.° / Stations. | Elevation in Meters. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Puerto Barrios | 2 | 23.5 | 24 | 24.5 | 26.5 | 27.5 | 29.5 | 26.33 | 26.20 | 26.75 | 27.0 | 26.5 | 23.75 |
| Salamá . . . . | 920 | 20.0 | 21 | 23.25 | 24.75 | 25.33 | 25.33 | 24.75 | 24.25 | 24.0 | 21.5 | 21.75 | 20.75 |
| Campur . . . . | 930 | 17.75 | 19.5 | 19.75 | 21.75 | 23.0 | 22.0 | 21.0 | 20.75 | 20.75 | 20.75 | 18.75 | 16.5 |
| Chimax . . . . | 1,306 | 16.5 | 16.75 | 18.33 | 19.66 | 20.0 | 19.66 | 19.25 | 19.5 | 20.12 | 18.5 | 16.33 | 16.0 |
| Guatemala . . | 1,485 | 16.0 | 17.5 | 18.5 | 19.5 | 19.75 | 19.0 | 18.5 | 18.5 | 18.5 | 18.0 | 16.75 | 16.5 |
| Quezaltenango | 2,350 | 10.5 | 11.75 | 13.75 | 15.25 | 17.0 | 16.75 | 16.0 | 15.75 | 16.5 | 15.25 | 14.5 | 12.0 |

the valley of the Motagua River. Its maximum is about sunrise, and the minimum between two and three o'clock in the afternoon depending upon the temperature. Thunderstorms are frequent from May to September, but seldom occur during other parts of the year. They come mostly in the afternoon between halfs past two and half past six o'clock.

*It is a general rule with regard to* rainfall *that regions confronting moist winds from the ocean have an abundant precipitation, and that regions defended by mountain ranges from the sea winds are dry. Guatemala having a complicated topographic configuration has for this reason great varieties of rainfall.* Frosts have been observed only in regions above 5900 feet (1800 m) elevation and snow has been seen in regions above 10,170 feet (3100 m).

Particulars are found in the accompanying table of average rainfall in millimeters for different regions.

| Rainfall in Mm. / Stations. | Elevation in Meters. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Puerto Barrios | 2 | 140 | 155 | 85 | 155 | 160 | 320 | 500 | 490 | 280 | 160 | 430 | 240 |
| *Cubilguitz* . . . | *300* | *180* | *210* | *125* | *70* | *260* | 380 | 520 | 300 | 540 | 590 | 400 | 280 |
| Setal. . . . . . | 720 | 470 | 300 | 270 | 70 | 300 | 520 | 620 | 500 | 430 | 620 | 360 | 420 |
| Salamá . . . . | 920 | 0 | 0 | 0 | 0 | 90 | 180 | 100 | 70 | 110 | 20 | 60 | 0 |
| Senahu . . . . | 990 | 130 | 100 | 80 | 105 | 500 | 620 | 800 | 580 | 450 | 360 | 160 | 115 |
| Las Mercedes. | 1,000 | 35 | 60 | 100 | 215 | 445 | 560 | 470 | 560 | 540 | 480 | 135 | 60 |
| Chimax . . . . | 1,306 | 140 | 110 | 100 | 60 | 200 | 320 | 310 | 210 | 240 | 250 | 210 | 170 |
| Guatemala. . . | 1,485 | 10 | 8 | 5 | 20 | 75 | 140 | 280 | 275 | 225 | 225 | 180 | 15 |
| Quezaltenango | 2,000 | 0 | 0 | 0 | 5 | 90 | 160 | 100 | 75 | 120 | 75 | 20 | 10 |

## b. Nicaragua.

The climate of Nicaragua is determined by its position in the tropics, by the proximity of two great oceans, which gives to the country the regular temperature of an island, and by its topography. The prevailing wind is northeast. In the time of solstice, the direction of the wind changes to southwest, but variable winds without determined influence mostly blow at the time of the equinoxes. There are two well marked seasons; a dry season called summer, and a wet season called winter, along the Pacific coast, in the lake

region and still further inland along the Cordilleras de las Andes. On the Atlantic side of the Cordilleras, the rainfall does not entirely cease at any season, and the country there has the character perpetual spring, although the people distinguish between a summer and a winter. There the summer begins in January and ceases with the end of May. The prevailing northeast wind coming from the Atlantic is full of moisture, which, on its passage over the forests that cover nearly the whole Atlantic slope, is condensed and falls repeatedly but irregularly in showers. During the rest of the year the rain falls heavily, only temporarily interrupted in August and October, which short and comparatively dry seasons the people call "veranillos".

The rainy season, or winter, on the Pacific side begins generally about the middle of May and ends in the middle of November. Here, too, but generally in the month of August, one, or more, veranillo are observed. The hottest months in general are May and August, when the sun is in the zenith, but sometimes they occur later.

The rainy season is the pleasanter, for then the temperature is most uniform and the sky full of clouds. As rainfall and temperature vary according to locality, the following types are given, taken from observations of Dr. ERNEST ROTHSCHUH at the Hacienda Rosa de Jericho in Matagalpa in the high mountain region of Nicaragua over 3300 feet above the sea. During the period of his observations from January 1893, to March, 1894 there were rainfalls every month.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1893. | January | 17 | days. | May | 24 | days. | September | 30 | days. |
| | February | 17 | » | June | 29 | » | October | 28 | » |
| | March | 10 | » | July | 31 | » | November | 20 | » |
| | April | 9 | » | August | 27 | » | December | 21 | » |

1894. January 30 days; February 20 days; March 18 days.

There were heavy tropic rainfalls ("aguaceros") five times in January 1893, once in March, once in April, twice in May, once in June, six times in July, once in August, once in September, ten times in October, twice in November, twice in December, six times in January, 1904, five times in February, once in March. Thunderstorms were only observed from September to December inclusive; namely, sixteen times in September, two times in October, twice in November, once in December. They occurred during the afternoon or night time.

The maximum temperature was in January 1893, 82.9° F. (28.3° C.); in February 86° F. (30° C.); in March 86.1° F. (30.1° C.); in April 90° F. (32.2° C.); in May 82.5° F. (28.1° C.); in June 80.6° F. (27° C.); in July 76° F. (24.4° C.); in August 83.4° F. (28.6° C.); in September 78° F. (25.5° C.); in October 77.3° F. (25.2° C.); in November 74.8° F. (23.8° C.); in December 71.4° F. (21.9° C.); in January 1894, 68° F. (20° C.); in February 68.1° F. (20.1° C.); in March 69.8° F. (21° C.).

The minimum temperature stood a follows:

| | | | | |
|---|---|---|---|---|
| 1893. | January | 59° F. (15° C.) | July | 59° F. (15° C.) |
| | February | 62.6° F. (17° C.) | August | 59° F. (15° C.) |
| | March | 58.2° F. (14.6° C.) | September | 59.7° F. (15.4° C.) |
| | April | 62.9° F. (17.2° C.) | October | 57.7° F. (14.3° C.) |
| | May | 59° F. (15° C.) | November | 56.4° F. (13.6° C.) |
| | June | 59.9° F. (15.5° C.) | December | 52.1° F. (11.2° C.) |

1894. January 55° F. (12.8° C.); February 52.2° F. (11.4° C.); March 54.6° F. (12.6° C.).

The average temperature of the entire year was 62.9° F. (17.2° C.); the entire rainfall 96 inches (244 cm).

Another meteorologic type, from the Atlantic region from the observations of Dr. J. E. HUBBERT made for the Nicaragua Canal Company at San Juan for the year 1890 is given in the adjoining table.

| | Total Rainfall. mm | Average Temperature C. | Maximum Temperature C. | Minimum Temperature C. |
|---|---|---|---|---|
| January | 670 | 23.5° | 27.0° | 21.0° |
| February | 171.5 | 24.0° | 26.5° | 22.0° |
| March | 148.25 | 24.5° | 27.0° | 23.5° |
| April | 452.5 | 23.5° | 26.0° | 22.0° |
| May | 123.25 | 24.0° | 26.5° | 22.0° |
| June | 1171 | 26.5° | 29.0° | 23.0° |
| July | 1313.75 | 26.0° | 27.0° | 23.5° |
| August | 893 | 26.0° | 27.25° | 23.5° |
| September | 203.5 | 28.0° | 32.0° | 23.5° |
| October | 609 | 24.5° | 26.75° | 23.0° |
| November | 638.75 | 24.25° | 27.5° | 21.5° |
| December | 1041.25 | 24.25° | 27.0° | 22.0° |
| Total | 7435.75 | — | — | — |

For the Pacific side there are observations from the city of Rivas, about 177 feet above the sea, situated between the great lake of Nicaragua and the Pacific Ocean. During one year the mean highest temperature was 86° F. (30° C.); the mean lowest 70.7° F. (21.5° C.) and the mean average of a year 77.9° F. (25.5°).

Owing to its varied topography Nicaragua has its tierra caliente, its tierra templada and its tierra fria. The Atlantic and Pacific coast lands, except where broken by mountains, as well, as the plains surrounding the lakes and also the valley of the San Juan River are regarded as tierra caliente. The tierra templada is found on the slopes of the volcanoes and also on the mountain ridges along the Pacific, as well, as on some slopes of the Cordilleras of Nueva Segovia, Jinotega, Matagalpa and Chontales. In the highlands of these departments and on the higher mountains is found the tierra fria with pine and oak forests.

## c. Costa Rica.

The climate of Costa Rica depends on its situation in the tropics, on the position of the sun at different times of the year, and on the topography, but owing to the narrowness of the country and its situation between the two great oceans, it is well-tempered by the alisios (northeast trades) and other winds. The prevailing wind is from the northeast, or, better north-northeast and east. During August, September and October an increase of the northwest winds causes the heavy rains of that season. West-northwest and northwest winds blow also from May to August. The coldest month is January; December and February are relatively cold. The hottest months are May and June. The course of the temperature has all the characters of an insular climate, without having so much humidity. The oscillation of the average temperature is greatest in March and during the dry season, as at that time the sky is clear and the soil exposed to uninterrupted insolation during the day, while the earth's radiation of heat during the night is rapid. The daily oscillation is considerable also during the dry season, and continues during the first month of the rainy season, according to the conditions of the sky.

The sky in San José is ordinarily clear between midnight and noon, even during the most rainy months, and cloudy the rest of the twenty-four hours. Although the rainfall is abundant here from May to October, with rare exceptions they do not last more than a few hours each day. The mornings are generally splendid and the air very pure, and nearly every day the sunset can be clearly observed. From May to November, there are about two hours of copious rain daily between one and four o'clock in the afternoon, averaging, with great regularity, from ten to twelve inches a month, and from seventy to eighty inches during the year. Towards the end of June, there is a short dry period called »Veranillo de San Juan«. Through the Desengano and Palma passes, the northern rains penetrate a short distance every day, and the northern descent of the Palma Pass toward Carillo is probably the most rainy district of the republic.

The rainy season on the Caribbean slope of the country does not correspond to that of the Pacific. In fact, there are no continuously dry months, and on the northern declivities of the volcanos Turrialba, Irazu, Barba and Poas, it rains more or less during the entire year; also near Lake Nicaragua, it rains nearly continuously, and the mountains of the Guatuso country and the surroundings of the volcano of Orosi are seldom without clouds. At times there are cloudbursts of tremendous power, broadening rivers for miles.

The climate of Talamanca in very unhealthy in proximity to the coast, and in the lower course of the rivers a similarly deadly climate prevails. In normal years, there are two dry and two wet seasons. The rains commence regularly in May or June and last until the end of July. The months of August and September are more or less dry. In October, there are some heavy showers, and extensive rains begin which characterize the months of November, December and January. The driest months are February, March and April. The high region is extremely humid, giving rise to fogs and rains.

The accompanying tables present the details of the meteorology of Costa Rica.

Climatology of Costa Rica communicated by H. PITTIER, Director, Physico-Geographic Institute. Hourly observations at the Observatory, San José de Costa Rica, during (February) 1903. (Total for day only given). Temperature in Fahrenheit. Monthly Weather Review XXXI. 1903.

| | | Temperature F. | | Relative Humidity % | | Rainfall. (Ins.) | |
|---|---|---|---|---|---|---|---|
| | | Observed 1903. | Normal 1889—1900. | Observed 1903. | Normal 1889—1900. | Observed 1903. Total. | Normal 1889—1900. Total. |
| January | Mean | 66.6 | 65.8 | 73 | 77 | 0.19 | 0.46 |
| | Minimum | 53.4 | 49.5 | 20 | — | — | — |
| | Maximum | 85.5 | 86.5 | 100 | — | — | — |
| February | Mean | 68.4 | 66.7 | 69 | 73 | 0.01 | 0.06 |
| | Minimum | 57.9 | 46.8 | 32 | — | — | — |
| | Maximum | 84.4 | 89.6 | 100 | — | — | — |
| March | Mean | 67.4 | 67.6 | 68 | 73 | 0.11 | 0.48 |
| | Minimum | 51.1 | 49.8 | 23 | — | — | — |
| | Maximum | 86.0 | 90.7 | 96 | — | — | — |
| April | Mean | 68.5 | 68.7 | 66 | 74 | 0.98 | 1.68 |
| | Minimum | 53.6 | 51.4 | 8 | — | — | — |
| | Maximum | 88.9 | 94.5 | 100 | — | — | — |
| May | Mean | 68.4 | 68.8 | 81 | 82 | 14.60 | 9.15 |
| | Minimum | 56.5 | 53.4 | 40 | — | — | — |
| | Maximum | 85.5 | 90.5 | 100 | — | — | — |
| June | Mean | 68 2 | 68.2 | 84 | 85 | 13.41 | 11.42 |
| | Minimum | 59.5 | 55.8 | 47 | — | — | — |
| | Maximum | 84.2 | 85.1 | 100 | — | — | — |
| July | Mean | 67.7 | 67.7 | 84 | — | 8.39 | 9.49 |
| | Minimum | 57.2 | 55.8 | 46 | — | — | — |
| | Maximum | 84.7 | 84.6 | 100 | — | — | — |
| August | Mean | 66 6 | 67.5 | 85 | 84 | 10.14 | — |
| | Minimum | 56.1 | 55.8 | 44 | — | — | — |
| | Maximum | 81.7 | 84.7 | 100 | — | — | — |
| September | Mean | 67.4 | 67.6 | 81 | 86 | 9.83 | 12.29 |
| | Minimum | 55.0 | 55.9 | 33 | — | — | — |
| | Maximum | 84.7 | 86.0 | 100 | — | — | — |
| October | Mean | 67.0 | 67.3 | 84 | 87 | 11.83 | 12.80 |
| | Minimum | 56.8 | 56.1 | 44 | — | — | — |
| | Maximum | 83.8 | 84.7 | 100 | — | — | — |
| November | (vacat). | | | | | | |
| December | Mean | 64.8 | 65.9 | 82 | 79 | 5.24 | 1.55 |
| | Minimum | 57.4 | 48.6 | 33 | — | — | — |
| | Maximum | 82.9 | 84.6 | 100 | — | — | — |

Temperatures (F.) of Soil at Depths of San José (Mean).

| 1903 | 6 inches. | 12 inches. | 24 inches. | 48 inches. |
|---|---|---|---|---|
| January . . . | 72.0 | 72.1 | 72.1 | 70.9 |
| February . . | 75.2 | 74.9 | 74.5 | 71.7 |
| March . . . . | 73.6 | 73.7 | 74.0 | 72.0 |
| April . . . . | 73.0 | 73.0 | 73.5 | 71.6 |
| May . . . . . | 73.2 | 73.2 | 73.9 | 72.6 |
| June . . . . . | 71.6 | 71.8 | 72.5 | 72.0 |
| July . . . . . | 70.3 | 70.6 | 71.4 | 71.5 |
| August. . . . | 70.3 | 70.3 | 71.1 | 70.6 |
| September. . | 70.6 | 70.6 | 71.3 | 70.6 |
| October . . . | 71.1 | 71.0 | 71.5 | 70.9 |
| December . . | 67.5 | 67.6 | 68.8 | 69.5 |

Observation taken at Port Limon (Pl.: 10 feet elevation) and Zent (Z.: 66 feet elevation) Costa Rica. Monthly Weather Review. XXXI. 1903.

| | | Temperature Fahrenheit. | | | Relative Humidity. | Rainfall. | | Temperature of Soil at Depth of | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Mean. | % | Amount Inches. | Number of Days. | 6 in. | 12 in. | 24 in. |
| January | Pl. | 64.4 | 87.8 | 76.8 | 84 | 15.39 | 19 | — | — | — |
| | Z. | 63.5 | 93.2 | 76.6 | 91 | 9.72 | 16 | 77.4 | 77.2 | 77.1 |
| February | Pl. | 64.4 | 87.8 | 75.9 | 83 | 0.79 | 10 | — | — | — |
| | Z. | 65.3 | 89.6 | 77.3 | 81 | 6.73 | 22 | 77.0 | 77.7 | 77.5 |
| March | Pl. | 62.6 | 86.0 | 76.0 | 85 | 3.07 | 9 | — | — | — |
| | Z. | 57.2 | 95.0 | 76.6 | 83 | 15.00 | 15 | 79.6 | 79.1 | 79.2 |
| April | Pl. | 62.6 | 86.0 | 75.9 | 81 | 12.28 | 6 | — | — | — |
| | Z. | 50.9 | 95.0 | 77.4 | 83 | 13.74 | 11 | 81.0 | 80.6 | 80.2 |
| May | Pl. | 66.2 | 86.0 | 76.1 | 77 | 0.65 | 5 | — | — | — |
| | Z. | 51.2 | 95.0 | 79.5 | 81 | 2.91 | 15 | 82.0 | 81.8 | 81.1 |
| June | Pl. | 64.4 | 86.5 | 76.4 | 80 | 2.68 | 8 | — | — | — |
| | Z. | 66.2 | 91.0 | 79.0 | 85 | 5.91 | 15 | 82.5 | 82.2 | 81.5 |
| July | Pl. | 66.2 | 89.1 | 77.9 | 83 | 9.17 | 21 | — | — | — |
| | Z. | 65.3 | 89.6 | 78.0 | 87 | 7.33 | 19 | 80.4 | 80.4 | 80.4 |
| August | Pl. | — | — | — | — | 1.85 | 6 | — | — | — |
| | Z. | 66.2 | 91.6 | 79.1 | 82 | 3.82 | 17 | 81.1 | 81.1 | 81.1 |
| September | Pl. | — | — | — | — | 1.02 | — | — | — | — |
| | Z. | 65.5 | 90.1 | 82.2 | 83 | 2.64 | 10 | 82.4 | 81.3 | 81.1 |
| October | Pl. | — | — | — | — | — | — | — | — | — |
| | Z. | — | — | — | — | 12.56 | 10 | — | — | — |
| December | Pl. | — | — | — | — | — | — | — | — | — |
| | Z. | 65.1 | 87.6 | 74.1 | 90 | 45.24 | 30 | 76.1 | 76.2 | 76.6 |

## d. Panama.

In considering the climate of the Isthmus, as compared with that of more temperate regions, attention is attracted to the remarkable uniformity of the temperature throughout the year. The general elements which determine this

*uniformity are the direct heat received from the sun; the influence of the successive volume of aqueous vapor held in suspension in the atmosphere; the influence of the two great seas which wash the shores of the narrow belt of* land connecting North and South America. The influence of the seas depends on their varying absolute temperatures and on the movements of the atmosphere, as these, in a large measure regulate the effect of the oceans in different months. The curves indicating the influence of the two oceans show that the Atlantic is much the more important. The northerly winds prevailing in the first four months of the year effectually prevent the Pacific, then relatively cold, from moderating the temperature at Panama. The joint influence of varying humidity and varying length of night is a more powerful factor in affecting the nearly unvarying annual temperature of the Isthmus than perhaps *has been appreciated hitherto.*

Observed Air Temperature on the Isthmus [1].

| Month. | *Colon* 92 months. °C. | *Gamboa* 58 months. °C. | Alhajuela 39 months. °C. | *Panama* 9 months. °C. | *La Boca* 41 months. °C. | *Naos* 70 months. °C. | Mean. °C. | Mean. °F. |
|---|---|---|---|---|---|---|---|---|
| January | 26.65 | 24.10 | 24.96 | 26.17 | 26.20 | 26.60 | 25.71 | 78.28 |
| February | 26.18 | 23.60 | 26.06 | 26.25 | 26.79 | 26.15 | 25.84 | 78.51 |
| March | 26.47 | 24.15 | 26.55 | 26.62 | 27.25 | 26.33 | 26.23 | 79.21 |
| April | 26.48 | 24.90 | 27.05 | 27.25 | 27.69 | 27.65 | 26.84 | 80.31 |
| May | 26.73 | 26.85 | 25.55 | 27.07 | 27.01 | 27.90 | 26.85 | 80.33 |
| June | 26.73 | 27.70 | 26.21 | 26.69 | 27.23 | 28.85 | 27.23 | 81.01 |
| July | 26.77 | 26.75 | 26.02 | — | 26.69 | 28.31 | 26.91 | 80.44 |
| August | 26.23 | 26.60 | 26.20 | — | 26.10 | 28.00 | 26.63 | 79.93 |
| September | 26.57 | 27.15 | 25.97 | — | 26.46 | 27.94 | 26.82 | 80.28 |
| October | 26.18 | 26.55 | 25.46 | 26.45 | 25.84 | 27.45 | 26.32 | 79.38 |
| November | 26.10 | 26.80 | 25.60 | 26.01 | 25.79 | 26.80 | 26.18 | 79.12 |
| December | 26.47 | 25.75 | 25.76 | 25.78 | 26.48 | 26.80 | 26.17 | 79.11 |
| Means | 26.43 | 25.91 | 25.95 | 26.48 | 26.63 | 27.40 | 26.48 | 79.66 |

As is the case with the monthly means, the changes of temperature from hour to hour and from day to day are subject to much less variation on the Isthmus than in regions more remote from the equator. In connection with this study the fact that the rainfall on the Caribbean shore of South America is much less than in Panama, should be noted. During the period of observations made there the average annual rainfall was, at Alhajuela, 103.8 inches; at La Boca, 74.5 inches; at Barbados, 39.6 inches; at Trinidad, 56.5 inches; *and at Curacao only 16.1 inches. It is evident from an inspection of the accompanying consolidated table to February 1903 that an annual rainfall of* about 140 inches may be expected on the Atlantic coast, about 93 inches in the interior, and about 60 inches near the shores of the Pacific. There is a

1) ABBOTT, General HENRY L.: Climatology of the Isthmus of Panama. Monthly Weather Review XXXI: 119. March 1903.

well-defined dry season beginning in December and including the months of January, February, March and part of April, a period during which the sun is returning northward from his southern journey to the Tropic of Capricorn, and the locus of heavy rainfall has been transferred southward from the Isthmus. This comparative exemption from rain is characteristic of the interior and of the Pacific coast, but somewhat less so of the region bordering the Caribbean Sea.

Rainfall in inches, consolidated to February 1903[1].

| Month. | Atlantic Coast. | | Pacific Coast. | | | | Means. | |
|---|---|---|---|---|---|---|---|---|
| | Colon (32). | Bohio (6). | Panama (4). | Naos (7). | Tobago (3). | La Boca (4). | Atlantic (38). | Pacific (18). |
| January . . . | 3.89 | 9.34 | 0.70 | 0.50 | 0.17 | 1.07 | 6.62 | 0.83 |
| February . . | 1.44 | 1.50 | 0.73 | 0.08 | 0.00 | 0.03 | 1.47 | 0.21 |
| March . . . . | 1.58 | 2.29 | 1.56 | 0.35 | 0.00 | 1.55 | 1.94 | 0.86 |
| April. . . . . | 4.32 | 4.94 | 2.84 | 1.71 | 0.81 | 3.72 | 4.63 | 2.27 |
| May . . . . . | 12.04 | 13.90 | 7.58 | 4.77 | 6.34 | 9.81 | 12.97 | 7.12 |
| June . . . . . | 13.50 | 13.31 | 7.86 | 5.49 | 8.16 | 8.23 | 13.40 | 7.44 |
| July . . . . . | 16.70 | 18.13 | 7.58 | 4.29 | 6.15 | 10.17 | 17.42 | 7.05 |
| August. . . . | 15.13 | 20.50 | 6.81 | 4.78 | 7.12 | 5.39 | 17.82 | 6.03 |
| September . | 12.68 | 16.73 | 7.48 | 7.42 | 7.33 | 7.31 | 14.70 | 7.38 |
| October . . . | 14.15 | 20.44 | 9.49 | 6.64 | 7.32 | 11.12 | 17.30 | 8.64 |
| November. . | 20.69 | 20.15 | 11.57 | 6.26 | 4.05 | 10.43 | 20.42 | 8.08 |
| December. . | 12.14 | 9.25 | 2.75 | 3.21 | 6.56 | 4.78 | 10.70 | 4.33 |
| Total . . . . | 128.26 | 150.48 | 66.78 | 45.50 | 54.01 | 74.51 | 139.69 | 60.24 |

During seven months, from October, 1898, to May, 1899, the United States *Weather Bureau made continuous observations* upon the velocity of wind at *Colon*[2]. *These velocity observations constitute the only direct measurements ever reported on the Isthmus.* They show during the whole period a great uniformity from day to day, from month to month, the wind increasing gently from about six miles per hour at midnight at two or three o'clock in the afternoon, and then subsiding gradually. The strongest winds came from the Caribbean Sea, usually attaining a velocity of about 20 miles per hour, and on one occasion a velocity of 24 miles.

## 5. West Indies.

The islands of the West Indies with the exception of part of the Bahamas lie between the isotherms of 77° F. (25° C.) and 82° F. (27.8° C.). The extreme heat is greatly tempered by the sea breezes, and by long, cool, refreshing nights, while in the higher mountainous parts of several of the islands (15,500 square miles (40,145 qkm) lie at an elevation of more than 1500 feet above the sea level), a marked degree of coolness may generally be found. The short wet season, or spring, begins in April and lasts from two to six weeks, and

1) ABBOTT, General HENRY L.: loc. cit. p. 122.

2) ABBOTT, General HENRY L.: loc. cit. p. 123.

is succeeded by the short dry season, when the thermometer remains almost stationary at about 80° F. In July, the heat increases to an extent well night unbearable. From the end of July to the beginning of October, the greatest rainfall of the season commences accompanied by destructive hurricanes. Out of a total of 355 hurricanes recorded during the last three hundred years, 42 have occurred in July, 96 in August, 80 in September and 69 in October. These storms commence in the Atlantic and toward the east. They follow a westerly course for a day, or two, inclining at the same time, one or two points towards the north, the polar tendency becoming gradually more marked as the distance from the equator increases. When the hurricanes reach 25° N., they curve to the northeast and almost invariably wheel round on arriving at the northern portion of the Gulf of Mexico, after which they follow the coast line of North America. December marks the commencement of the long dry season, which accompanied by fresh winds lasts till April.

## a. Cuba.

Extensive climatologic data are not available for Cuba. The eastern chain of mountains, the Sierra Maestra, probably presents conditions of temperature very nearly the same as the Blue Mountains of Jamaica. Every-where the rains are most abundant in summer the rainy season from May to October. The winds brought by the trade-winds are heavier and more frequent on the higher slopes of the eastern end, although these are more arid and near sea-level. At Havana, the annual rainfall is 51.73 inches and of the total 32.37 inches fall in the wet season. The average number of rainy days in the year is 102. The warmest months at Havana in July and August, the average temperature is 82° F. (27.8° C.) fluctuating between a maximum of 88° F. (31.1° C.) and a minimum of 76° F. (24.4° C.), while a temperature as high as 100° F. (37.8° C.) has been recorded. In the cooler months of December and January, the thermometer averages 72° F. (22.2° C.) maximum being 78° F. (25.6° C.); the minimum 50° F. (10° C.). The average temperature of the year is 77° F. (25° C.).

At Santiago de Cuba, the temperature is apparently higher than on the northern and western coasts and from the meager data available appears to be about 80° F. (26.7° C.) with an average difference between the warmest and coldest months of about 6° F. The prevailing wind is the northeast trade, but from November to February, cool north winds are experienced in the western part of the island. Ordinarily from ten to twelve o'clock are the hottest hours of the day for in the afternoon a refreshing breeze (la virazon) sets in from the sea.

## b. Santo Domingo.

The climate of the island of Santo Domingo is more diversified than that of any of the other islands of the Greater Antilles. It presents wide extremes of temperature, moisture and aridity. The heat at the capital of Haiti, Port

au Prince, owing to its sheltered situation is probably greater than at any seaport in the West Indies, reaching 94° to 96° F. (34.4°—35.6° C.) every day between April and October. The nights are on an average 10° to 20° cooler than the days and consequently they seem cool and pleasant in comparison with the heat of the day. This is true of the so-called rainy season, the rains falling, as a rule, late in the afternoon, or early in the evening. The temperature on the other hand during the rest of the year, which covers the dry season from October to April, is on an average about 10° lower.

## c. Jamaica.

The varied surface of Jamaica, with altitudes ranging from sea-leval to 7360 feet (2243 m), that of Blue Mountain Peak, affords a range of climate which leaves little to be desired. The annual rainfall is 67 inches (170 cm). The island is naturally divided into four rainfall divisions. The northeastern and northern divisions have winter rains in November, December and January. These rains are brought by the east or northeast winds, and fall day and night. The northeastern and west central divisions have summer rains. These rains come as rule during the summer afternoons from enormous cumulus clouds piled up the height of 5 or 6 miles, and they are accompanied with much thunder and lightning. The southern division is dry having rains for the most part only during the summer months on a grand scale, and in the central line of hills heavy rains occur every afternoon from the beginning of May to the end of October.

The general average temperature is remarkably uniform throughout the island. The temperature varies with the altitude. The diurnal variations are as different as the circumstances of each locality, and according as sunshine, cloud morning fog, afternoon rains, wind and calms prevail, so will the characteristics of the diurnal variation change; but generally the minimum temperature occurs between dawn and sunrise. The temperature rises rapidly from 7 a. m. to 9 a. m. when the sea breeze begins to blow and checks the rate of increase. The maximum occurs between noon and 1 p. m. (clouds or rain keep the afternoons fairly uniform, but the clear evenings allow the temperature to fall at once, the minimum occurring, as already said, a little before sunrise. The following table shows the decrease of temperature with elevation in Jamaica[1]).

| Stations. | Elevation feet. | Barometric Pressure inches. | Temperature (F.). | | | |
|---|---|---|---|---|---|---|
| | | | Mean. ° | Max. ° | Min. ° | Range. ° |
| Kingston . . . . . . . | 50 | 29.95 | 78.1 | 87.8 | 70.7 | 17.1 |
| Kempshot . . . . . . | 1773 | 28.20 | 72.7 | 80.5 | 68.0 | 12.5 |
| Cinchona Plantation . | 4907 | 25.27 | 62.6 | 68.5 | 57.5 | 11.0 |
| Portland Gap . . . . | 5477 | 24.71 | 59.7 | 69.0 | 54.6 | 14.4 |
| Blue Mountain Peak . | 7360 | 23.14 | 55.7 | 71.1 | 46.3 | 24.8 |

1) Report of the international meteorological Congress held at Chicago, Illinois, August 21—24, 1893; Washington Bulletin No. 11 Part III, Weather Bureau 1896: 591.

The highest and lowest temperatures recorded in Kingston, Jamaica since 1880, when regular observations were commenced, are 96.7° F. (36° C.) and 56.7° F. (13.7° C.) respectfully. In the following tables the meteorologic observations at Kingston for ten years from June 1880, to May 1890 inclusive are given.

| Month. | Temperature, Mean (° Celsius). | Temperature (F.). Mean. ° | Max. ° | Min. ° | Range. ° | Cloud per cent. | Rainfall. Kingston inches. | The Islands inches. |
|---|---|---|---|---|---|---|---|---|
| January . . . . . . . | 23.6 | 74.6 | 86.4 | 66.8 | 19.6 | 29 | 0.96 | 3.87 |
| February . . . . . . | 23.7 | 74.7 | 85.8 | 66.8 | 19.0 | 27 | 0.32 | 2.62 |
| March . . . . . . . . | 24.3 | 75.8 | 85.7 | 67.8 | 17.9 | 29 | 1.59 | 2.88 |
| April . . . . . . . . . | 25.5 | 77.9 | 86.5 | 69.8 | 16.7 | 39 | 1.02 | 4.18 |
| May . . . . . . . . . . | 26.3 | 79.4 | 87.2 | 72.4 | 14.8 | 56 | 6.00 | 8.40 |
| June . . . . . . . . . | 27.1 | 80.8 | 88.5 | 73.8 | 14.7 | 57 | 5.51 | 7.83 |
| July . . . . . . . . . . | 27.3 | 81.1 | 89.7 | 73.5 | 16.2 | 52 | 2.15 | 4.32 |
| August . . . . . . . . | 26.9 | 80.4 | 89.4 | 73.2 | 16.2 | 55 | 4.09 | 6.83 |
| September . . . . . | 26.7 | 80.1 | 89.7 | 73.3 | 16.4 | 62 | 3.59 | 6.86 |
| October . . . . . . . . | 26.0 | 78.9 | 88.9 | 72.1 | 16.8 | 58 | 4.69 | 7.84 |
| November . . . . . . | 25.4 | 77.8 | 88.9 | 70.7 | 18.2 | 44 | 1.22 | 5.07 |
| December . . . . . . | 24.3 | 75.7 | 87.0 | 68.4 | 18.6 | 38 | 1.50 | 5.60 |
| Means . . . . . . . . | 25.6 | 78.1 | 87.8 | 70.7 | 17.1 | 55 | — | — |
| Totals . . . . . . . . | — | — | — | — | — | — | 32.64 | 66.30 |

## d. Puerto Rico.

The average daily temperature of the island is 80° F. (26.7° C.), which is ameliorated by a cool north breeze which generally prevails on the hottest days. The mean monthly temperature of the capital, San Juan, for a period of twenty years is 78.8° F. (26.1° C.). The maximum attained only three times during this period was 99° F. (37.2° C.) and the minimum 57.2° F. (14° C.). The temperature rises to 88° F. (31.1° C.) at midday, and sinks to 80.6° F. (27° C.) at night. It stands ordinarily on the cool mornings at 69.8° F. (21° C.), but falls sometimes as low as 60.8° F. (16° C.). The coolest places in the island are found in the interior highlands, where the nights are always cool.

June, July, August and September are the hottest months, while December, January and February are the coolest. The cold winds, which blow down from the mountains in the other islands, are seldom felt in Puerto Rico, though tropic hurricanes are frequent between July and October.

The average rainfall has been 59.5 inches (143 cm) for the past twenty years. The month of February is the driest month, when less than two inches of rainfall. January and March have less than three inches, December less than four. Five inches of rainfall occur in the remaining months April to November inclusive. The greatest quantity of the year, 7.62 inches (19 cm) is precipitated in November. During the hottest months, it rains hard and abundantly. The fall of rain comes in heavy gusts with strong winds between noon and four p. m. An hour later the skies appear in beautiful colors of gold, violet, purple and

blue. A bright, cool starlight night usually follows. East and north winds set in toward the end of October. The first brings heavy rains, and the latter gentle showers, though on the south side of the island great draughts occur.

## e. The Bahamas.

The climate of the Bahamas is agreeable and healthful, but subject to greater extremes of heat and cold than the other islands of the West Indian group. The temperature varies from 60° to 75° F. (15.6°—23.8° C.) during the winter months from November to May, while the remainder of the year constitutes the warm season with a temperature between 75° and 85° F. (23.8°—29.4° C.). The lack of elevation allows the full effects of the sea-breezes to be felt, and these breezes temper to some extent the heat of midday.

## f. The Bermudas.

The islands are on the eastern edge of the Gulf Stream, by which very naturally the climate is influenced. The surface temperature of the water averages 70° F. (21.1° C.). For ten years the mean temperature of the air registered 71° F. (21.7° C.), the dew-point being 64° F. (17.8° C). The highest temperature observed in the shade was 90° F. (32.2° C.). and the lowest 48° F. (8.9° C.), but in the sun a greater temperature has been reached than 90° F. (32.2° C.). August is the hottest month, averaging 87° F. (30.5° C.); February the coldest month, 55° F. (12.7° C.). The daily range is six to eight degrees and the annual about thirty-two degrees. In making a comparison with the United States, it may be said that the isotherm of 72° F. (22.2° C.) runs across the middle of Florida and through the Bermuda group of islands. The rainfall is large. The average of ten years shows 155 rainy days in 356, and 56 inches. The distribution through the year is very uniform.

In the following table the meteorologic observations at Hamilton for the year 1903 are given (furnished by the Canadian Meteorological Service 1903).

| Month. | Temperature (F°). | | | | Precipitation (Ins.). | |
|---|---|---|---|---|---|---|
| | Mean. | Departure from normal. | Mean maximum. | Mean minimum. | Total. | Departure from normal. |
| January | 64.2 | +2.2 | 69 | 59 | 4.37 | −0.57 |
| February | 64.0 | +2.5 | 70 | 58 | 1.44 | −3.00 |
| March | 65.8 | +3.6 | 70 | 62 | 4.06 | −1.07 |
| April | 66.0 | +2.1 | 71 | 61 | 4.20 | +0.02 |
| May | 68.2 | −1.2 | 73 | 63 | 3.98 | −0.68 |
| June | 73.0 | −2.0 | 78 | 68 | 3.83 | −2.12 |
| July | 78.7 | +0.3 | 85 | 73 | 1.73 | −2.71 |
| August | 81.2 | −1.6 | 88 | 74 | 3.85 | −2.23 |
| September | 78.4 | +1.0 | 83 | 73 | 8.38 | +1.87 |
| October | 72.6 | −0.4 | 77 | 68 | 9.83 | +3.12 |
| November | 68.3 | −0.4 | 73 | 63 | 5.03 | +0.65 |
| December | 64.4 | −0.3 | 69 | 60 | 10.58 | +6.09 |

# Chapter III. Statistics of North American Plants.

The number of species of plants in North America can be stated only approximately, because the total is subject to change with the exploration of territory unknown botanically and with the advance of our knowledge as to the systematic relationship of plant species. For the United States and Canada, we have fairly accurate data, but for Mexico, Central America and the West Indies, we can make only an estimate, because these tropic countries are still too little known. There is a tendency manifested among American botanists to multiply species, it seems to the writer to an undue extent. For example in the two years 1898 to 1900 about 2000 new plants names were published, representing *bona fide* new plants, but in addition the reinstatement of names established by NUTTALL, PURSH and other botanists, who were actually acquainted with the plants, they described and whose names were suppressed by later botanists less familiar with the plants as they occur in the fields and forests. There is a growing disposition to discard the use of varietal names, and to call all plants species which have characters sufficiently distinct to justify the use of a specific name. Accordingly, many varieties have been raised to specific rank. At the present rate of activity in systematic botany, the year 1908 will see a list of about 22,000 American plant names. HELLER (1900) in his Catalogue of North American Plants, North of Mexico, exclusive of the lower cryptogams enumerates 16,673 plants.

SERENO WATSON in the sixth edition of GRAY's Manual (1890) which classifies the plants of the northern United States, including the district east of the 100th meridian and north of North Carolina and Tennessee, gives a list of orders with the number of genera and species native and introduced. He enumerates 251 native and 46 introduced genera and 777 native species; 141 introduced species of apopetalous dicotyledonous plants. Of gamopetalous plants, there are 245 native genera, 53 introduced genera, 874 native species and 148 introduced species within the region covered by the manual. The apetalous dicotyledons comprise 76 native genera, 7 introduced genera, 257 native species and 51 introduced. The conifers consist of 10 native genera and 22 species. Of monocotyledonous plants there are 170 native genera, 22 introduced genera, 721 native species and 64 introduced species. The pteridophytes include 29 native genera with 102 native species, and the bryophytes 44 native genera, 1 introduced genus, 140 native and 1 introduced species. Summing up we have a total of 834 genera of native, 129 genera of introduced plants, 2893 native species and 405 introduced species of plants; total 963 genera and 3298 species of plants.

The last (seventh) edition of Gray's New Manual of Botany (1908, illustrated) rewritten by B. L. ROBINSON and M. L. FERNALD gives this summary of the total number of different plants (species, varieties and named forms) found in the region east of the 96th meridian of longitude, south of the 48th parallel

of latitude from the Gulf of St. Lawrence to Lake Superior, north of the southern boundaries of Kansas, Missouri, Kentucky and Virginia[1]).

| Division, Class etc. | Genera. | | Species. | | Varieties and Named Forms. | |
|---|---|---|---|---|---|---|
| | Native. | Introd. | Native. | Introd. | Native. | Introd. |
| Pteridophyta | 31 | — | 115 | | 61 | — |
| Spermatophyta | 790 | 180 | 3298 | 666 | 705 | 40 |
| Gymnospermae | 10 | — | 25 | 3 | 2 | — |
| Angiospermae | 780 | 180 | 3273 | 663 | 703 | 40 |
| Monocotyledoneae | 184 | 26 | 993 | 92 | 236 | 5 |
| Dicotyledoneae | 596 | 154 | 2280 | 571 | 467 | 35 |
| Total | 821 | 180 | 3413 | 666 | 766 | 40 |
| | 1001 | | 4079 | | 806 | |
| Whole number of different plants | | | 4885 | | | |

*For the same region, including the British possessions from Newfoundland* to the parallel of the southern boundary of Virginia and from the Atlantic Ocean westward to the 102d meridian, BRITTON in his Illustrated Flora (1898 presents a summary which is found in the following table:

| | Genera. | Species. |
|---|---|---|
| Pteridophyta | 30 | 115 |
| Spermatophyta | — | — |
| Gymnospermae | 10 | 27 |
| Angiospermae | — | — |
| Monocotyledoneae | 217 | 1058 |
| Dicotyledoneae | — | — |
| Choripetalae | 468 | 1601 |
| Gamopetalae | 378 | 1361 |
| Total | 1103 | 4162 |

In the Flora of the Southeastern United States by JOHN K. SMALL (1903), including a systematic description of the plants growing naturally in North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Indian Territory, Oklahoma and Texas east of the 100th meridian, we have described 1494 genera and 6364 species of plants. JOHN MACOUN in his Catalogue of Canadian Plants enumerates 3209 species of flowering plants including the gymnosperms and pteridophytes and approximately 933 species of true mosses (Musci frondosi).

AXEL RYDBERG gives a summary of Rocky Mountain species of plants known in 1900 in his Catalogue of the Flora of Montana and the Yellowstone National Park. It appears that there are 659 species of plants strictly endemic to the Rocky Mountains found in the region included in the

1) *Book first issued September 22, 1908.*

above mentioned catalogue with a total of 1976 species, 163 new to science. That COULTER's Manual of the Rocky Mountain Region (1885) does not include more than a fair representation of the plants of that floral region is indicated by the fact that RYDBERG describes in his monograph 776 species not mentioned in COULTER's Manual.

We have no detailed statistics of the species comprising the Pacific coast flora, but a count of those described in JEPSON's Flora of Western Middle California gives 1463 species as the total number found west of the Sacramento and San Joaquin rivers, south of the counties of Mendocino, Lake and Colusa and north of the Pajaro River and Pacheco Pass. A Flora of Northwest America comprises descriptions of 3052 speeies found growing without cultivation north of California, west of Utah and south of British Columbia.

The total number of flowering plants in Mexico and Central America according to HEMSLEY in Biologia Centrali-Americana published some years ago is 11,626, of which total 8193 species are endemic, 2930 grow in north Mexico, 5848 in south Mexico, and 1337 species known for Guatemala. Mexico, Guatemala and Honduras have 6693 endemic species. Nicaragua has 843 species accredited to her, Costa Rica 1086 and Panama 1436, while the endemic plants for Nicaragua, Costa Rica and Panama represent 1076 species. The number of species for Mexico and the other states has been greatly augmented by the discoveries of C. C. PALMER, C. G. PRINGLE, JOHN DONNELL SMITH, J. N. ROSE and other botanists, so that the numbers given above must be considerably increased to accurately depict the statistics of the flora.

GRISEBACH in his Flora of the British West Indian Island (1864) by a count of Professor KRUG gives the following number of species for the several islands named Bermudas 17, Bahamas 19, Turk's Island 21, Jamaica 2301, Cuba 1051, Haiti 324, Puerto Rico 92, while the total number of species for the Windward, as well, as the Leeward islands and Trinidad given in the work is 3143 spermatophytes and 366 pteridophytes. This represents the botanic knowledge of the West Indies in GRISEBACH's day. Our information concerning the flora of these islands has been augmented vastly and the lists of species for the different islands, while still far from complete, are of considerable length. The following enumeration categorically represents the available statistics for the Greater Antilles, and the Bahamas.

## Cuba.

According to GRISEBACH[1]) the flora of Cuba consists of

| | | | |
|---|---|---|---|
| Dicotyledoneae . . . . . | 2350 | endemic | 781 |
| Monocotyledoneae . . . | 643 | » | 148 |
| Vascular Cryptogams . . | 279 | » | 10 |
| | 3272 | » | 939 |

1) GRISEBACH: *Catalogus Plantarum Cubensium 1866.*

A later enumeration is a follows[1]):

| | Species. | | Total. |
|---|---|---|---|
| | Indigenous. | Naturalized. | |
| Thallophyta. . . . . | 230 | 15 | 254 |
| Bryophyta. . . . . | 59 | 1 | 60 |
| Pteridophyta . . . . | 200 | 3 | 203 |
| Gymnospermae . . . | 13 | 1 | 14 |
| Monocotyledoneae . | 812 | 6 | 818 |
| Dicotyledoneae . . . | 2266 | 72 | 2338 |
| | 3649 | 98 | 3747 |

## Jamaica, Santo Domingo, Puerto Rico and St. Croix.

According to the Provisional List of the Indigenous and Naturalized Plants of Jamaica by WILLIAM FAWCETT (1893) there are 2130 species of flowering plants in Jamaica and according to JENMAN approximately 450 species of ferns and fern allies. We have no recent statistic data as to the floras of these two islands, but in URBAN's Flora Portoricensis, which is being issued from Berlin, the number of pteridophytes and monocotyledons is 684 species. Our knowledge of the flora of Santo Domingo is yet too scanty to permit of even an approximate estimate, but from what botanic exploration of that island has already yielded the number of plants that will probably be revealed will far exceed that of any one of the other West Indian islands. The number of species growing in the island of St. Croix is 1029 according to MILLSPAUGH[2]), who has made (1902) the latest study of the flora.

## Bahamas.

According to the exploration of ALICE R. NORTHROP (1902) the total number of plants found on New Providence and Andros islands, exclusive of cultivated and escaped plants, is 453 of which 176 species are reported from other islands of the group. HITCHCOCK on the other hand in his account of the flora of the group, published in the report of the Missouri Botanical Garden for 1893, gives as the total for the Bahamas 380 species. — COKER in his report to the Geographical Society of Baltimore (Vegetation of the Bahama Islands 1905: 194) enumerates 795 Bahaman plants, comprising those reported by himself, Millspaugh, Hitchcock, Northrop, Grisebach, Urban and Herrick, together with those in the unpublished lists of Curtiss, Britton and Millspaugh.

1) MANUEL GOMEZ DE LA MAZA JIMENEZ: Flora de Cuba. Habana 1887.

2) MILLSPAUGH, C. F.: Flora of the Island of St. Croix. Field Columbian Museum. Botanical Series I, No. 7. November 1902.

# Part III.

## Geologic Evolution, theoretic Considerations and Statistics on the Distribution of North American Plants.

### Chapter I. Cretaceous and Tertiary Floras.

*Beginning of the actual Flora.* The history of the flora of North America, as it concerns this book, begins with the Cretaceous period when the land and water stood in a vastly different relationship than they do at present. That the subsequent shifting of the continental areas with respect to the oceans had great influence on the evolution of plant form and the distribution of species cannot be gainsaid. It is beyond the province of this work to deal with the speculations upon this subject, but it will suffice to refer to such facts as bear upon the subsequent distribution of plant life in North America.

The dicotyledonous angiosperms, which at present form the predominant vegetation of North America, occur in the beginning of the upper Cretaceous, or at the close of the lower Cretaceous. The reign of the cyads and pines holds throughout the lower Cretaceous. If we examine a geologic map of the North American continent, we find that the northern and central part of the continent was cut off from South America by a sea, which covered Mexico and connected the Atlantic and Pacific oceans (see Fig. 1). The coniferous vegetation was, as paleontologic evidence shows, of the same general type all over the continent. In the upper Cretaceous more of Mexico was submerged and an arm of the American Mediterranean extending across the continent northward, covered the present states of Texas, New Mexico, Colorado, Kansas, Wyoming, Montana, etc. to the Arctic Ocean. It was then, the author believes, and not with the oncoming of the glacial period as TRANSEAU claims, that the beginning of the assortment of the coniferous vegetation into the eastern and western types took place (see Fig. 2, p. 172). The upper Cretaceous period was sufficiently long to permit of the adjustment of the old types to the new environmental conditions and the evolution of new forms, for we have a great and sudden inswarming of the higher plants of modern types at the close of the lower

*Cretaceous.* SAPORTA [1]) *is struck by this phenomenon of the sudden appearance of so many forms, and some of them the most highly differentiated of dicotyledonous plants. The early stages of their evolution may he thinks have been obscure, and as yet unobserved, or they may have taken place in some*

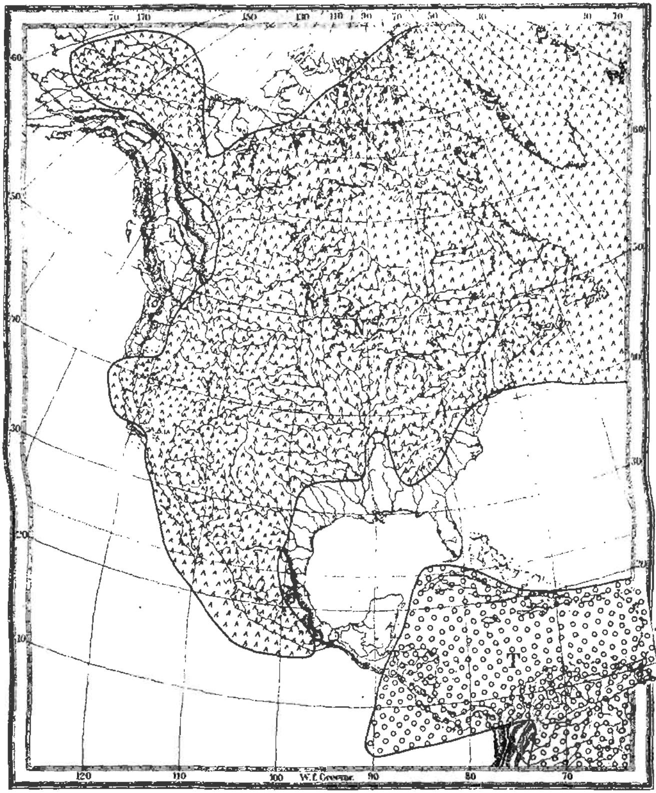

Fig. 1. Map illustrating position and extent of Land during the lower Cretaceous Period, as well as the Distribution of Land Plants.

N Northern Coniferous Forest Types. T Tropic Types of Vegetation.

1) SAPORTA, Monde des Plantes p. 197.

separate region, or mother country, as yet undiscovered, or they may have been produced by a rapid and unusual multiplication of flower-haunting insects. None of these propositions of SAPORTA satisfactorily explain the facts. The

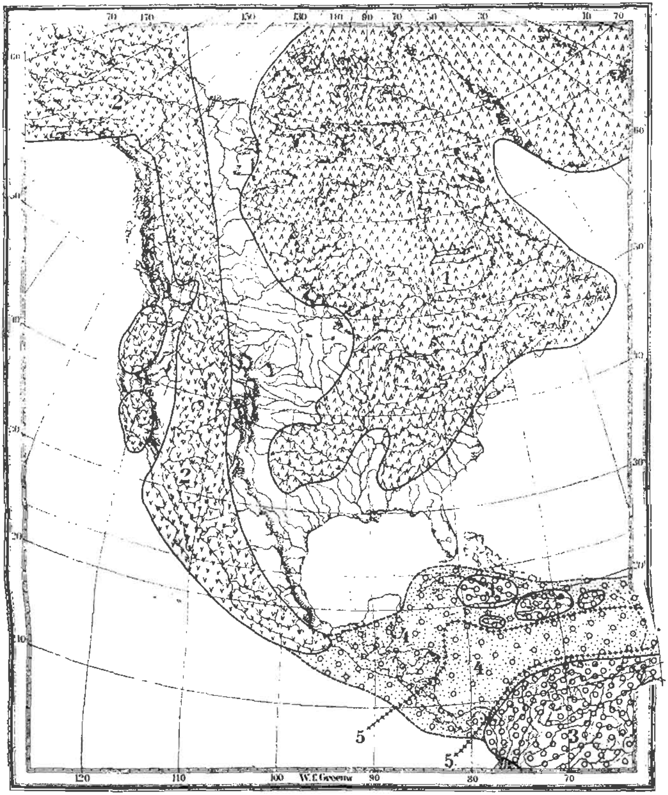


Fig. 2. Map illustrating position and extent of Land during the Cretaceous Period, as well as the Distribution of Land Plants.

1 Eastern Dicotyledonous Vegetation. 2 Western Types of Vegetation. 3 Tropic Types of Vegetation. 4 Land Bridge, according to Ortmann, connecting northern South America, West Indies and Mexico with Tropic Vegetation. 5 Very late Cretaceous and early Tertiary Submergence with Formation of Caribbean Sea.

lower Cretaceous period was one of rapid physiographic change. ALFRED RUSSELL WALLACE[1]) follows BALL's hint as to the cause of the late appearance of the exogens. The suddenness of their appearance, he notes must be only apparent, being "due to unknown conditions which have prevented their preservation, or their discovery in earlier formations"[2]). The erosion of material and its transport supposes rapidly moving water in which the stone and soil particles are being ground against each other and rounded off by constant attrition. Suppose a luxuriant vegetation of monocotyledons and dicotyledons to be in process of evolution in such a region, what would be the influence of the physical conditions of a region undergoing base-leveling upon the preservation of plant remains? The preservation of plant remains would be very precarious. The soil of the hillsides might have been either too dry, the flow of the streams too rapid, the grinding together of the rocks and gravel too great to permit of the fossilization of the vegetal remains, which require sedimentation of the material transported.

Naturally this sedimentation did not take place in regions of rapid base-leveling, or in a region where lakes were and are absent, and we must, therefore, appeal to these facts in order to explain the absence of fossil remains from large districts of the earth's surface. According to DARWIN[3]), it is the "imperfection of the geological record", which precludes the possibility of deciding definitely, as to the exact past vegetal covering of any particular geographic district.

*Evolutionary Principle.* From the paleontologic evidence, it seems probable that a rapid and extensive development of new plant forms took place during the Cretaceous period. The theories of DE VRIES on the origin of species enable us to suggest the reasons for this evolution of new forms. DE VRIES has recourse to a periodicity of variation. Mutability occurs only at certain periods, and a species might continue existence indefinitely without giving rise to new forms. If this periodicity of mutation is recognized as an evolutionary principle, we have a reasonable explanation for the sudden appearance of so many new forms during the Cretaceous period for during this stage of the development of the vegetable kingdom, through causes yet unknown, the progenitors of the existing phanerogams were in a high state of mutability giving rise to new elementary species. DE VRIES emphasizes this as the method of the origin of species, for in his words: new elementary species may appear suddenly without transition, or intermediate forms between them and their immediate ancestors; and therefore the new species were constant from the moment of their origin[4]).

1) WALLACE, Darwinism. Humboldt Library edition, p. 270.

2) WOODWORTH, American Geologist. Oct. 1894. XIV p. 231.

3) DARWIN, Origin of Species, heading Chapter X.

4) MACDOUGAL: The Origin of Species by Mutation. Torreya Vol. 2, May, June, July 1902. — This has not been the only method of the origin of new species, which may have arisen by hybridization, by small increments of variation, by isolation and by adaptation to environment, or acclimatization. (HARSHBERGER.)

*Evolution of the forests.* The great feature of the Cretaceous period was its dicotyledonous forests (see Fig. 2) and an enumeration of the genera is sufficient to show the richness of the flora at this time. As the remains are largely leaves and fruits, trees and shrubs predominate in the lists given by phytopaleontologists, but the presence of arborescent species and ferns presupposes the presence of numerous herbaceous plants which owing to their herbaceous, or succulent character failed of preservation.

But the Miocene period is of greatest interest to the phytogeographer. Much of our knowledge has been obtained through the researches of GOEPPERT, HEER, LESQUEREAUX, UNGER, ETTINGSHAUSEN, STARKEY GARDNER, WARD, GRAY and KNOWLTON. We know that during the close of the Cretaceous, the Eocene and Miocene periods a forest of great denseness existed in northern North America, extending far north into the arctic regions. This flora consisted of a great variety of trees and shrubs found in North America today, and in addition of many related genera and species which are at present extremely local in distribution, or have become extinct. Many of the descendants of this flora exist, as will be shown later in this chapter, in widely separated districts, such as Japan, China, eastern America, Pacific America and Europe. HEER in 1874[1]) called attention to the fact that out of the 353 plants known from the Miocene flora of the arctic region the following extended from Greenland to the Mackenzie River: *Taxodium distichum*, *Glyptostrobus Ungeri*, *Sequoia Langsdorfii*, *Populus arctica*, *Salix Racana*, *Corylus Macquarrii*, *Platanus aceroides*, *Hedera Macclurii* existed in Alaska and on the island of Sachalin, off the north coast of Japan, while *Alnus Kefersteinii*, *Betula prisca*, *Corylus insignis*, *Carpinus grandis*, *Castanea Ungeri* and *Juglans acuminata* grew in Spitzbergen, Greenland and Iceland[2]).

*The relict Miocene flora.* There are Tertiary genera of plants not found in Europe today which are prominent elements of the North American flora and which remain as relicts of that Miocene forest flora which spread across the northern hemisphere into Europe and Asia[3]). Such genera, as *Liriodendron*, *Magnolia*, *Vitis*, *Liquidambar*, *Sassafras*, *Aralia* and *Nyssa*, exemplify the fact which GRAY and LESQUEREUX emphasized that the present flora of northeastern America shows the strongest relationship to the Miocene flora of Greenland and North America including the territory west of the Mississippi. Many North American trees at present existing can be positively identified with Tertiary species. Such a similarity exists between the following list due to ENGLER[4]):

1) HEER: Nachträge zur miocenen Flora Grönlands, Kongl. Svenska Vetensk Acad. Handl. 1874. XIII. 2.

2) ENGLER: Versuch einer Entwickelungsgeschichte der Pflanzenwelt. 1. Theil, 1879, pp. 3—4.

3) GRAY, Darwiniana 1877 p. 228. — ENGLER: Grundzüge der Entwicklung der Flora Europas seit der Tertiärzeit. Botan. Jahrbücher Bd. XXXVI, Heft 4, Beibl. Nr. 81, pp. 5—27.

4) ENGLER: Versuch einer Entwickelungsgeschichte der Pflanzenwelt. 1. Theil, p. 5.

| *Miocene* | *Living* |
|---|---|
| Populus balsamoides Goepp. | Populus balsamifera L. |
| Platanus aceroides Goepp. | Platanus occidentalis L. |
| Juglans bilinica Unger<br>» longifolia Heer | Juglans nigra L. |
| Vitis teutonica A. Br. | Vitis vulpina L. |
| Tilia Malmgreni Heer | Tilia americana L. |
| Liquidambar europaeum A. Br.<br>» protensum Unger | Liquidambar styraciflua L. |
| Magnolia primigenia Unger | Magnolia grandiflora L. |
| Liriodendron Procaccinii Unger[1] | Liriodendron tulipifera L. |
| Sassafras Aesculapi Heer | Sassafras officinalis Nees. |
| Taxodium distichum L. | Taxodium distichum L. |
| Sequoia Langsdorfii A. Br. | Sequoia sempervirens Endl. |
| » Sternbergii Goepp. | » gigantea Lindl. |

The climate of the Eocene and Miocene periods was milder than at present and over much of North America was somewhat sub-tropic in character. This warm zone extended well into the Arctic regions and a temperature comparable to that of southern New England, or New Jersey existed in far northern latitudes. It is not to be wondered at that we find preserved as relicts of a lower Miocene flora (upper eocene of Lesquereux[2]) such subtropic genera, as *Carya*, *Cassia*, *Cinnamomum*, *Cissus*, *Ficus*, *Laurus*, *Morus*, *Persea*, *Personia*, and *Rhus* and that a large number of palm species of the genus *Sabal* occur on the upper Missouri. The abundant brown coal layers of Grinnell Land[3]) 81° 46′ north latitude reveal a flora of birches, poplars, elms, lindens, hazelnuts, *Taxodium*, *Picea excelsa*, and pines similar in constitution to that which we find at the present in 50° to 60° north latitude, except that the northern limit of *Taxodium* at present is about 39° north latitude. To find a similar tropic flora today, we must visit 15° or 25° north latitude, where we enter a region in which grow many species of *Carya*, *Cassia*, *Ficus* and genera of the natural order Lauraceae. The species of *Sabal* and *Chamaerops* (*Rhapidophyllum!*) occur in South Carolina and Florida.

If it is not possible to arrange all of the fossil genera and species with reference to their past distribution, it is possible to positively assert, that in northwest America during the younger Tertiary, or Neogene (comprising the Miocene and Pliocene) occurred such living genera, as *Betula*, *Diospyros*,

1) Considerable doubt has been thrown on these fossil species of tulip tree because all of the fossil leaf forms have been duplicated from living trees. See in this connection. — Holm: Notes on the leaves of Liriodendron. Proceedings National Museum, XIII, pp. 15—35. 1890, plates IV—IX.

2) Lesquereux, L.: American Journal Science and Arts. 1874: 399.

3) Heer, O.: Flora fossilis arctica V. 1878.

*Fagus*, *Liquidambar*, *Liriodendron*, *Magnolia*, *Sassafras*, which are known from the Dakota formations (Upper Cretaceous). The following Dakota species of fossil plants may be compared with those of the present flora —

| | |
|---|---|
| Hedera ovalis Lesq. | Hedera helix L. |
| Laurus macrocarpa Lesq. | Persea carolinensis Catesb. |
| Liquidambar integrifolium. | Liquidambar styraciflua L. |
| Liriodendron sp. | Liriodendron tulipifera L. |
| Menispermites | Menispermum canadense L. |
| Platanus primaeva Lesq. | Platanus occidentalis L. |
| Rhus sp. | Rhus metopium L. |
| Sassafras sp. | Sassafras officinale L. |

Some of the peculiarities of the past and present distribution of plants are made clear by a study of the coniferous vegetation of America. Many living conifers are extremely localized in their distribution, but before the glacial period many of them extended over a great portion of the northern hemisphere. *Libocedrus decurrens* a tree restricted to California with a representative in Chili and in the South Sea islands occurred during Miocene times in Spitzbergen with two species. — *Sequoia gigantea* which grows in the Sierra Nevada Mountains of California occurred in Greenland in a related species *S. Sternbergii*. *Sequoia sempervirens* of the north California coast is related to *S. Langsdorfii*, which occurred in the arctic regions and eastern Asia.

The majority of the very numerous North American conifers belong to separate sections of pines, as *Pinaster*, *Taeda*, *Pseudo-Strobus*, *Cembra* and to the genera *Abies*, *Cupressus*, *Juniperus*, *Picea*, *Thuja* and *Tsuga*. Of these, only a few are represented in Tertiary deposits, namely, remains of *Abies* and *Thuja* in Montana and Wyoming. More extensive remains of conifers occur in the north, for example in Banksland 74° 27' *Abies Armstrongii* and *Picea Maccluri* related to the modern *Picea alba* are found with a single species of *Pinus*; in Grinnell Land 81° 46' *Taxodium*, *Feildenia*, *Pinus* and *Pinus excelsa*, while in Spitzbergen and Iceland occur remains of such genera as *Tsuga* and *Juniperus*.

The following *List of Cretaceous and Tertiary plants of North America* up to 1898 taken from KNOWLTON[1]) will give a more adequate impression of the somewhat uniform flora which extended from the arctic regions through America far to the south. The number of recognized species in each case is given and genera only are mentioned about which there can be no doubt as to their identity.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Abies | 1 | Acer | 23 | Acorus | 3 | Aesculus | 1 |
| Abietites | 11 | Aceriphyllum | 1 | Acrostichopteris | 5 | Alnus | 15 |
| Acacia | 2 | Acerates | 1 | Acrostichum | 2 | Amelanchier | 4. |

1) KNOWLTON, F. H.: A Catalogue of Cretaceous and Tertiary Plants of North America Bulletin U. S. Geological Survey No. 152. Washington 1898.

| | |
|---|---|
| Ampelopsis | 1 |
| Amygdalus | 1 |
| Andromeda | 25 |
| Anemia | 4 |
| Angiopteridium | 11 |
| Anisophyllum | 2 |
| Anomozamites | 4 |
| Anona | 2 |
| Aralia | 38 |
| Araucaria | 4 |
| Araucarioxylon | 2 |
| Araucarites | 3 |
| Arisaema | 3 |
| Aristolochia | 4 |
| Aristolochites | 2 |
| Artocarpus | 2 |
| Arundo | 2 |
| Asimina | 2 |
| Aspidiophyllum | 3 |
| Aspleniopteris | 2 |
| Asplenium | 13 |
| Arthrotaxopsis | 4 |
| Baiera | 4 |
| Baieropsis | 10 |
| Banksia | 2 |
| Banksites | 1 |
| Bauhinia | 2 |
| Benzoin | 3 |
| Berberis | 1 |
| Berchemia | 1 |
| Betula | 27 |
| Betulites with vars. | 21 |
| Blechnum | 1 |
| Bombax | 1 |
| Brachyphyllum | 7 |
| Brasenia | 2 |
| Bromus | 1 |
| Pryum | 1 |
| Bumelia | 2 |
| Cabomba | 2 |
| Caesalpinia | 1 |
| Carex | 7 |
| Carpinus | 4 |
| Cassia | 6 |
| Castalia | 4 |
| Castanea | 6 |
| Castanopsis | 1 |
| Casuarina | 1 |
| Catalpa | 1 |
| Ceanothus | 4 |
| Cebatha | 1 |
| Cedroxylon | 1 |
| Celastrophyllum | 26 |
| Celastrus | 16 |
| Celtis | 4 |
| Cephalotaxopsis | 6 |
| Cercis | 4 |
| Cercocarpus | 1 |
| Chamaecyparis | 1 |
| Chara | 4 |
| Cinnamomum | 16 |
| Cissites | 20 |
| Cissus | 7 |
| Cladophlebis | 28 |
| Clethra | 1 |
| Coccoloba | 1 |
| Colutea | 2 |
| Comptonia | 1 |
| Cornus | 16 |
| Corylus | 7 |
| Crataegus | 14 |
| Cunninghamites | 2 |
| Cupressinoxylon | 22 |
| Cycadeoidea | 11 |
| Cycadeospermum | 7 |
| Cycadites | 2 |
| Cyperacites | 9 |
| Cyperus | 4 |
| Cytisus | 2 |
| Dalbergia | 4 |
| Davallia | 1 |
| Dicksonia | 2 |
| Dioonites | 7 |
| Dioscorea | 1 |
| Diospyros | 21 |
| Drosera | 1 |
| Dryopteris | 21 |
| Elaeagnus | 1 |
| Elodea | 1 |
| Encephalartopsis | 1 |
| Encephalartos | 1 |
| Engelhardtia | 1 |
| Equisetum | 29 |
| Eucalyptophyllum | 1 |
| Eucalyptus | 9 |
| Eugenia | 1 |
| Euonymus | 2 |
| Fagophyllum | 1 |
| Fagus | 11 |
| Ficophyllum | 3 |
| Ficus | 99 |
| Fontinalis | 3 |
| Fraxinus | 15 |
| Fucus | 2 |
| Gaylussacia | 1 |
| Ginkgo | 13 |
| Gleditschia | 1 |
| Gleichenia | 6 |
| Glyptostrobus | 10 |
| Grewia | 5 |
| Grewiopsis | 13 |
| Gymnogramma | 3 |
| Hamamelites | 5 |
| Hedera | 15 |
| Hicoria (= Carya) | 9 |
| Hymenaea | 2 |
| Hymenophyllum | 2 |
| Hypnum | 7 |
| Ilex | 28 |
| Illicium | 1 |
| Inga | 1 |
| Isoetes | 1 |
| Juglandiphyllum | 1 |
| Juglandites | 7 |
| Juglans | 35 |
| Juncus | 1 |
| Juniperus | 2 |
| Kalmia | 1 |
| Laricopsis | 3 |
| Larix | 2 |
| Lastraea | 5 |
| Laurinoxylon | 3 |
| Laurophyllum | 5 |
| Laurus | 33 |
| Lemna | 3 |
| Leucothoe | 1 |
| Liquidambar | 4 |
| Liriodendron | 18 |
| Liriodendropsis | 2 |
| Liriophyllum | 3 |
| Lomatia | 9 |
| Lycopodium | 4 |
| Lygodium | 5 |
| Magnolia | 40 |
| Marsilia | 1 |
| Menispermites | 17 |
| Menyanthes | 1 |
| Microzamia | 1 |
| Morus | 2 |
| Myrica | 53 |
| Myrsine | 7 |
| Myrtus | 1 |
| Negundoides | 1 |
| Negundo | 1 |
| Nelumbium | 6 |
| Neuropteris | 2 |
| Nyssa | 12 |
| Olea | 1 |
| Onoclea | 2 |
| Ophioglossum | 1 |
| Oryzopsis | 1 |
| Osmunda | 6 |
| Ostrya | 3 |
| Oxycoccus | 1 |
| Paliurus | 16 |
| Passiflora | 1 |
| Pecopteris | 13 |
| Persea | 11 |
| Phegopteris | 1 |
| Phragmites | 6 |
| Picea | 3 |
| Pinus | 19 |
| Piper | 1 |
| Pisonia | 1 |
| Pistacia | 1 |
| Planera | 0 |
| Platanophyllum | 1 |
| Platanus | 30 |
| Poacites | 3 |
| Podocarpites | 1 |
| Podocarpus | 1 |
| Polypodium | 2 |
| Populites | 8 |
| Populophyllum | 3 |
| Populus | 84 |
| Potamogeton | 7 |
| Potentilla | 1 |
| Prunus | 6 |
| Pteris | 6 |
| Pterocarya | 2 |
| Pyrus | 1 |
| Quercophyllum | 2 |
| Quercus | 126 |
| Rhamnites | 3 |
| Rhamnus | 33 |
| Rhus | 30 |
| Rosa | 1 |
| Sabal | 4 |
| Sabalites | 3 |
| Saliciphyllum | 3 |
| Salix | 45 |
| Salvinia | 2 |
| Santalum | 1 |
| Sapindopsis | 8 |
| Sapindus | 20 |
| Sassafras | 25 |
| Scirpus | 2 |
| Selaginella | 3 |
| Sequoia | 44 |
| Smilax | 7 |
| Sparganium | 3 |
| Sphenopteris | 11 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Spiraea | 1 | Taxus | 1 | Ulmophyllum | 4 | Weinmannia | 3 |
| Staphylea | 1 | Thyrsopteris | 39 | Ulmus | 24 | Widdringtonia | 2 |
| Sterculia | 15 | Tilia | 2 | Vaccinophyllum | 1 | Woodwardia | 3 |
| Styrax | 1 | Tmesipteris | 1 | Vaccinium | 4 | Xanthoxylum | 3 |
| Symphorocarpophyllum | 2 | Toxylon (= Maclura) | 1 | Vallisneria | 1 | Zamia | 1 |
| Taeniopteris | 2 | Trapa | 5 | Viburnites | 3 | Zamiopsis | 13 |
| Taxites | 4 | Tsuga | 1 | Viburnum | 45 | Zizyphus | 16 |
| Taxodium | 9 | Tumion (= Torreya) | 5 | Vitiphyllum | 3 | Zostera | 1 |
| | | Typha | 2 | Vitis | 9 | | |

*Endemisms and glacial Plants.* The North American Tertiary flora composed of the species of the genera noticed above, as well, as of numerous herbaceous and arborescent species, that existed in the past, but have not been preserved, covered practically the entire land areas of the continent as it existed throughout the Cretaceous and Tertiary periods. The accompanying chart (see Fig. 3) will indicate that distribution, as determined theoretically from the relative position of the land and water areas, for it is clear, that the evolution of our present flora took place on dry land during and through the physiographic changes which were instrumental in the shaping of the continental land masses. As previously mentioned, the flora of the Eocene and the Miocene periods was fairly uniform in character from the Atlantic and Pacific oceans and from the American Mediterranean north and northwestward into the arctic regions and this flora was especially in the southern part of the Tertiary American continent of subtropic character. However, there appears to have been an indication, as early, as upper Cretaceous, of a separation of the eastern and western types of American vegetation, but this was not accentuated until the glacial period, because during Tertiary times, the western and the eastern parts of the continent were again united by a land connection.

We notice also a differentiation and isolation of certain Tertiary plants in the region of the southern Appalachian Mountains bringing about a peculiar relict endemism. This isolation probably began before the glacial period and was due to physiographic, rather than climatic causes. Oscillations of level, followed by erosion and base leveling, have been known to occur and to occupy vast periods of time, and we have then in the physiographic changes which have taken place in this mountain region an explanation of the peculiarities of the flora of the Southern Appalachians with its rich endemism. The presence of *Hudsonia montana* on the summit of Table Rock is thus explained, Table Rock is an undenuded remnant of a former peneplain, and it is likely that *Hudsonia montana* was once more extended in its distribution, but has been isolated by the erosion of the larger part of the plain on which it formerly grew [1]. The distribution of such local plants as *Dicentra eximia*, *Shortia galacifolia*, *Lilium Grayi*, *Buckleya distichophylla*, *Neviusia alabamensis*, *Elliottia racemosa* may have also a somewhat similar explanation.

1) HARSHBERGER: An ecological Study of the Flora of mountainous North Carolina loc. cit. pp. 247—248.

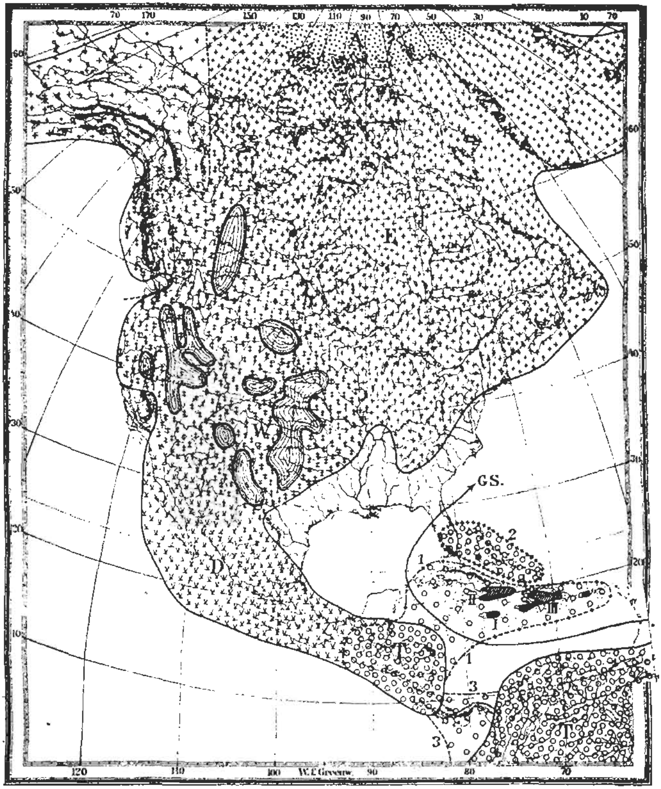


Fig. 3. Map illustrating position and extent of Land during lower Tertiary and Tertiary times, as well, as the Distribution of Plants.

A Arctic Flora. E Eastern Division of great Tertiary Forest. W Western Division of great Tertiary Forest. D Mexican Desert Types of Vegetation. T Tropical Types of Vegetation. L Interior Freshwater Lakes. GS Direction of Miocene Gulf Stream. 1 Eocene Land Connection; numbers I, II, III indicate order of final separation. 2 Miocene Florida-Bahama Connection. 3 Late Miocene Land Bridge.

The action of the several uplifts and depressions of the earth's surface was most profonnd upon the Tertiary forest, the history of which has been traced. With every submergence, the forest in the submerged area was destroyed, or if existing on higher ground was subjected to such extensive changes of level, as to highly modify its character and the distribution of the component species. Many species were crowded together by the change of level and the wearing away of the strata to which they had become adapted, for "if we suppose the earlier Mesozoic uplands to be the seat of the existing dicotyledons, then by the lowering of the surface by gradual consumption of the interstream areas, these forms must have been brought into conflict with the flora of the lowlands and thereby forced into a contest for supremacy [1]. Xerophytes of the hillsides and rock exposures are replaced by mesophytes, which thrive in rich alluvial soils; mesophytes by the wearing away of the soil and the formation of cliffs by xerophytes, such as exist on rocky outcrops; hydrophytes replace mesophytes, when an area becomes too wet for the tenancy of ordinary plants.

An arctic flora, consisting of glacial plants, must have existed north of the great Tertiary forest flora, for, we have the introduction of this element as a prominent one at the beginning of the glacial period, when the ice sheet moved south over the North American continent. This arctic flora must have been exceedingly circumscribed in the extreme north of the western hemisphere, while there is a probability, that it extended somewhat more to the southward in the eastern hemisphere. If we compare the number of Tertiary arctic plants and those of today, which although widely distributed in far distant lands, yet are undoubtedly of arctic derivation, we will according to theoretic reasons find a wide discrepancy in favor of the arctic plants of the present day floras. The ancient arctic flora was limited to the number of plants which had adapted themselves to the conditions of the polar lands in Tertiary times. The number of species was not so great, because the area to which they were confined was small and homogeneous and an excessive differentiation of new types could not take place. What the constitution of the original arctic flora was it is impossible to state. ENGLER believes that *Salix reticulata*, *S. polaris*, *S. herbacea*, *Cassiope tetragona*, *C. lycopodioides*, *C. hypnoides*, *Diapensia lapponica*, *Menyanthes trifoliata*, *Potentilla palustris*, *Scheuchzeria palustris*, *Eriophorum polystachyon*, *Drosera rotundifolia*[2]), *Vaccinium Oxycoccus*. *Chiogenes hispidula*, *Andromeda polifolia*, *Cassandra*, Cyperaceae and many others plants of the same species at present found in widely separated localities in America, Europe and Asia represent elements of such an ancient flora. It also implies that the great northern land masses must have been connected for a long time during the Tertiary period, so that migration of

1) WOODWORTH, J. B.: The Relation between baseleveling and organic Evolution. American Geologist XIV: 231 Oct. 1894; HARSHBERGER, J. W.: A phyto-geographic Sketch of extreme southeastern Pennsylvania. Bulletin Torrey Botanical Club XXXI: 129.

2) TRANSEAU, E. N.: On the geographic Distribution and geological Relations of the bog plant Societies of North America. Botanical Gazette XXXVI: 401—420.

plants in the circumpolar regions was by no means difficult. It is probable that in Scandinavia, Iceland, Greenland and North America many of the old glacial plants survived in the far north during the glacial period and that, therefore, the arctic region still contains endemic forms which have always been peculiar to it, such as, *Dupontia Fischeri* and *Pleuropogon Sabini*. The herd of glacial plants moved south from the far north into each one of the continental masses, America, Europe and Asia, where they were subjected to vicissitudes of climate to exposure to greater amounts of sunlight, where the physiographic and edaphic conditions were of great variety consisting of mountains, plains, valleys, sand hills, rock exposures, mud flats, bogs, moors and tundra. The outcome of such exposure to widely diverse conditions brought about a great differentiation of form and new species arose by mutation [1]. Space will not permit a differential exposition of the influences brought to bear upon the glacial flora along the southern edge of the great ice sheet. Where the vicissitudes were greatest and the edaphic and physiographic conditions nearly uniform, we find comparatively little differentiation of new types. The sparseness of the flora of the eastern United States, except Mount Washington and one or two other localities, in glacial plants is thus accounted for. The effect of the glaciation on the eastern United States was much more severe than in the western, because the mountains were lower and practically with the exception of Mount Washington and perhaps Mount Katahdin covered with the continental ice cap. The absence of true glacial plants on any of Alleghany mountain tops, or ranges, is accounted for by the fact that these mountains were not sufficiently high to support any local valley glaciers and because, as we will see in a short time in what follows, they were covered by dense vegetation which represented a relict of the great Miocene flora which previously covered the continent. — In the Rocky Mountains and on the Sierra Nevada Mountains of the western United States, the climatic conditions were such during the period of extreme glaciation as to encourage the differentiation of species by mutation, for the upper valleys of these ranges supported local glaciers and their summits were sufficiently high and the exposure to light and the edaphic conditions so diverse, as to supplement to an important extent the action of the climatic surroundings. We find in the Rocky Mountains, as we shall enumerate later, a comparatively rich glacier flora which persists today in many ranges, such as the Selkirks, and on such peaks as mounts Rainier, Shasta, Baker and Hood. With the retreat of the great continental ice sheet, the original arctic flora fled in part back to the arctic regions augmented by the new forms, which had been evolved during the glacial period on the mountains and along the southern limits of the ice sheet. As we will see shortly, many plants remained in the north on the nunataks

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1) Contrast the views of G. R. WIELAND in a paper entitled Polar Climate in Time the major Factor in the Evolution of Plants and Animals. American Journal Science XVI: 401—430 Dec. 1903.

and still others remained on the mountain summits not covered by the great ice sheet and migrated from these northward into the arctic regions again, or went south along the Rocky Mountains to form an element of the high mountain flora. The consequence of this shifting and migration was to produce at the present an arctic flora much richer in types, which were moulded by the changes into more plastic and world conquering forms.

We must believe that in the southwestern projection of the continent beginning even with the upper Cretaceous there was a flora practically distinct from the rest of the continent, because it was during this geologic period and the lower Tertiary that Mexico was under process of formation and these changes must have profoundly influenced the vegetation and its distribution. Such types as the various genera and species of the Cactaceae, Yucceae, and others which inhabit the Great Basin and arid southwest at the present day undoubtedly had their origin in the Mexican region and later during late Tertiary and post glacial times migrated northward into the present territory of the United States.

# Chapter II. History and Development of North American Flora during the Glacial Periods.

## 1. The Extension of the old Glaciers.

The history of the present flora of North America begins with Glacial period, when by a change of level in the North American continent, by an increase of precipitation and decrease of temperature, a great continental ice sheet covered the land mass at the north. The southern limit of the great glaciers is indicated by a vast deposit of morainic material which stretches across North America from the Atlantic to the Pacific oceans reaching in one of its lobes the Ohio River at the present Cincinnati. Three great centers of glaciation are recognized by geologists and glaciologists, viz., the Labrador center of the northeast, the Keewatin center west of the present Hudson Bay and the Cordilleran center along the Pacific Ocean. These were elevated above their present level, and from them continental glaciers descended southward across the continent, sending forward several well marked lobes, such as the Erie Glacier, the Saginaw Glacier, the Traverse Glacier, the Michigan Glacier, the Green Bay Glacier, the Chippewa Glacier, the Superior Glacier and Minnesota Glacier with driftless areas sometimes between these lobes [1]). The maximum period of glaciation with one, or two interglacial epochs lasted sufficiently long to profoundly modify the Tertiary flora and to introduce new factors into the distribution of plants.

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1) FENNEMAN, N. M.: On the Lakes of southeastern Wisconsin. Wisconsin Geological and Natural History Survey, Bulletin No. VIII Educational Series No. 2 1902 see chart p. 2.

With the coming of the cold, which closed the Tertiary and inaugurated the Glacial period, the consequent accumulation of ice on the northern continental areas destroyed the ancient plant formations and associations. The forests were broken down by the ice storms of winter and their remains were ground to pieces by the moving glaciers. The semitropic species were killed by the increasing cold and such genera as *Ficus*, *Cinnamomum*, *Eucalyptus*, *Laurus*, *Artocarpus*, *Myrtus*, *Piper*, were exterminated, and extensive swaths were cut into the Tertiary forest by the great ice sheet, and only those species survived in their old haunts south of the glaciers which were adapted, as species of *Liriodendron*, *Quercus*, *Fraxinus*, *Tsuga* and *Abies*, etc., to grow under the influence of the increasing cold. The ground they had covered south of and along the great terminal moraine afforded new areas for the occupancy of two classes of plants, arctic plants and glacial bog plants. By the reversal of the drainage lines and consequent destruction of low ground vegetation, new habitats suited to these plants arose in advance of the ice invasion, spreading away from the centers of ice accumulation. Where this migration moved to the west, the plants were later destroyed, but their southward extension brought them into areas which were not within reach of the subsequent ice invasion. But the fact, says TRANSEAU [1]), that the plants have survived the ice advances proves that they were easily able to establish themselves in new areas, as rapidly as the climate changed. Not more than five such geographic migrations of more or less latitude, corresponding with the five glacial extensions must have occurred. For during the intervals, when, as shown by the animal and plant remains found in interglacial deposits, the temperature was nearly as high, as at the present time.

The following tentative classification is proposed by CHAMBERLAIN [2]) for the drift deposits of the Mississippi Valley, which probably represent the several stages of advance and recession of the great ice sheet during the Pleistocene.

Glacial or Pleistocene Series.

(see Fig. 4 at the head of Chapter III.)

1. Albertan drift sheet.
    2. Interglacial deposits (Aftonian).
3. Kansan till-sheet.
    4. Interglacial deposits (Buchanan).
5. Illinois till-sheet.
    6. Interglacial deposits.
7. Iowan till-sheet.
    8. Interglacial deposits (Toronto) [3]).
9. Wisconsin till-sheets (earlier and later).

The Albertan stage is displayed in the Canadian province of Alberta, where the first formation of it was due to the extension of the glaciers eastward from the Rocky Mountains. Farther east, the till-sheet passes into the

1) TRANSEAU, E. N.: Botanical Gazette, loc. cit. p. 410.

2) SCOTT, W. B.: *An Introduction to Geology*, *1897*: *515*.

3) COLEMAN, A. P.: Glacial and interglacial Beds near Toronto. Journal of Geology IX: 310. May. June 1901.

Saskatchewan gravels laid down by the waters derived from the ice-front. The lowest drift deposits of the Mississippi Valley are provisionally regarded as equivalents of the Albertan drift. A great retreat of the ice, if not its entire disappearance brought about interglacial conditions at least in the Mississippi Valley (Aftonian stage). The land area exposed by the retiring ice was rapidly reclothed with vegetation which in many places in Iowa, Minnesota, etc., formed accumulations of peat, sometimes to the depth of 25 feet. The Kansas stage represents the greatest extension southwestward of the ice-sheet, when the glacier descended again from the north nearly to the mouth of the Ohio River and spread across Iowa and Missouri far into Kansas. Eastward, the ice-sheet extended across the Mississippi River into Illinois. Again came a time of retreat, when Kansan till was eroded, soil was formed and peat deposited upon it, derived from vegetation which a second time had migrated into the barren area (Buchanan stage). A renewed extension of the ice laid down the Illinois till-sheet. A fourth recrudescence of the glacier (Iowan stage) occasioned the deposit of another till-sheet of an extent not yet determined, which is best displayed in northeastern Iowa. This stage was followed by interglacial deposits which are perhaps contemperaneous with those which are so well shown near Toronto along the valley of the Don and at Scarborough Heights and elsewhere in Canada and are a possible equivalent of GEIKIE's Neudeckian of the old world. The beds form a succession of fine shales and sandstones, that lie between two sheets of glacial drift and contain fossil plants and animals forming a Pleistocene fossil flora and fauna[1].

## 2. The Pleistocene Flora.

With the exception of *Acer pleistocenium*, it is a noteworthy fact that all the plants of the Pleistocene flora were such as are now represented in the same localities, or, in the case of the Don Valley, by plants which find their most northern distribution at or near that region, and the somewhat unequal distribution thus indicated at once suggests definite climatic changes during Pleistocene time, as represented by the northern and southern migration of particular types of plants. The definite and abundant occurrence of *Maclura aurantiaca* (= *Toxylon pomiferum*), *Juniperus virginiana*, *Quercus obtusiloba*, *Q. oblongifolia*, *Asimina triloba*, *Chamaecyparis sphaeroidea* (= *Cupressus thyoides*) and *Fraxinus quadrangulata* points with out question to the prevalence of a much warmer climate than now prevails, while on the other hand, the equally abundant occurrence of the boreal types at Scarborough points to the existence of a colder climate at the time these deposits were laid down. It is, therefore, clear that in the region of Toronto during Pleistocene times

1) PENHALLOW, D. P.: Contributions to the pleistocene Flora of Canada. Transactions Royal Society of Canada, second ser. 1896—97. II. sect. IV: 59—77; do with a Committee, Canadian pleistocene Flora and Fauna British Association Advancement Science 1898: 522—529; DAWSON, J. W., and Committee, Canadian pleistocene Flora and Fauna British Association 1900: 1—12.

there were at least two distinct periods, characterised, on the one hand, by a climate equivalent to that of the middle United States at the present day, and, on the other hand, a climate equivalent to that of Quebec and Labrador. On the other hand, the flora of Green's Creek and that of Montreal is practically identical with that now existing in the same localities. It thus represents a climate colder than that of the Don period, but somewhat warmer than that of the Scarborough period, but present evidence does not enable us to ascertain, if these deposits were laid down before or after the Scarborough deposits. The following summary given by PENHALLOW (1900) will probably assist in conveying a clear idea of the distinctive differences in the vegetation of these three periods.

| Pleistocene Flora[1]. | Don Period. Warm Climate. | Scarborough Period. Cold Climate. | Green's Creek Period. Mild Climate. |
|---|---|---|---|
| Abies balsamea L. | — | + | — |
| Acer pleistocenium Dawson et Penhallow | + | — | — |
| Acer saccharinum Wangenh. (= A. saccharum Marsh.) | — | — | + |
| Acer spicatum Lam. | + | — | — |
| Algae sp. | — | — | + |
| Alnus sp. | — | + | |
| Asimina triloba L. | + | — | — |
| Betula lutea Michx. f. | — | — | + |
| Brasenia peltata Pursh. (= B. purpurea Michx.) | — | — | + |
| Bromus ciliatus L. | — | — | + |
| Carex aquatilis Wahl. | — | + | — |
| Carex magellanica Lam. | — | — | + |
| Carex reticulata Mill. | — | + | — |
| Carya alba Nutt. (= Hicoria ovata Mill.) | + | — | — |
| Chamaecyparis sphaeroidea Spach (= C. thyoides L.) | + | — | — |
| Crataegus punctata Jacq. | + | — | — |
| Cyperaceae | + | — | + |
| Drosera rotundifolia L. | — | — | + |
| Elodea canadensis Michx. (= Philotria canadensis Michx.) | — | — | + |
| Encyonema prostratum | — | — | + |
| Equisetum limosum L. | — | — | + |
| » scirpoides Michx. | — | — | + |
| » sylvaticum L. | — | — | + |

1) In this and all subsequent lists, the author cited is the one who first applied the specific, or varietal name to the plant, whether it was placed at first in the right, or the wrong genus.

| Pleistocene Flora. | Don Period. Warm Climate. | Scarborough Period. Cold Climate. | Green's Creek Period. Mild Climate. |
|---|---|---|---|
| Equisetum sp. | — | + | — |
| Eriocaulon sp. | + | — | — |
| Fontinalis sp. | — | + | + |
| Fucus digitatus | — | — | + |
| Fraxinus quadrangulata Michx. | + | — | — |
| » sambucifolia Lam. (= F. nigra Marsh.) | + | — | — |
| » americana L. | + | — | — |
| Festuca ovina L. | + | — | — |
| Gaylussacia resinosa Ait. | — | — | + |
| Gramineae sp. | — | — | + |
| Hypnum commutatum Hedw. | — | + | — |
| » fluitans L. | — | — | + |
| » revolvens Swartz | — | + | — |
| » sp. | + | — | — |
| Juniperus virginiana L. | + | — | — |
| Larix americana Michx. (= L. laricina Du Roi) | + | + | — |
| Lycopodium sp. | — | + | — |
| Maclura aurantiaca Nutt. (= Toxylon pomiferum Raf.). | + | — | — |
| Oryzopsis asperifolia Michx. | — | — | + |
| Oxycoccus palustris Pers. (= Vaccinium oxycoccus L.) | — | + | — |
| Picea alba Ait. (= P. canadensis Mill.) | — | + | — |
| Picea nigra Ait. (= P. mariana Mill.) | + | — | — |
| Picea sp. | + | — | — |
| Pinus strobus L. | + | — | — |
| Platanus occidentalis L. | + | — | — |
| Populus grandidentata Michx. | + | — | — |
| Populus balsamifera L. | + | — | — |
| Potamogeton pectinatus L. | — | — | + |
| » perfoliatus L. | — | — | + |
| » pusillus L. | — | — | + |
| » rutilus Wolfg. | — | — | + |
| » natans L. | + | — | — |
| Potentilla anserina L. (= Argentina anserina L.) | — | — | + |
| Prunus sp. | + | — | — |
| Quercus obtusiloba Michx. (= Q. minor Marsh.) | + | — | — |
| » rubra L. | + | — | — |
| » tinctoria Bartram (= Q. velutina Lam.) | + | — | — |
| » oblongifolia Torr. | + | — | — |

| Pleistocene Flora. | Don Period. Warm Climate. | Scarborough Period. Cold Climate. | Green's Creek Period. Mild Climate. |
|---|---|---|---|
| Quercus macrocarpa Michx. | + | — | — |
| » acuminata Michx. (= Q. Muhlenbergii Engelm.) | + | — | — |
| Robinia pseudacacia L. | + | — | — |
| Salix sp. | + | + | — |
| Taxus canadensis Marsh. | + | — | - |
| Thuja occidentalis L. | + | — | — |
| Tilia americana L. | + | — | — |
| Typha *latifolia* L. | + | — | — |
| Ulmus americana L. | + | — | — |
| » racemosa Thomas | + | — | — |
| Vaccinium uliginosum L. | — | + | — |
| Vallisneria spiralis L. | — | — | + |
| Zostera marina L. | — | — | + |
| Totals | 38 | 14 | 26 |

## 3. The Glacial Flora.

The Wisconsin stage, and last one, is the most conspicuous and best known of all, and its sheets of till and drift are far thicker than those of the other glacial stages. Especially conspicuous is the great terminal moraine, which has been traced across the continent.

The final retreat of the ice, of which in New England there is no clear evidence of more than one glacial stage, was by slow steps with many halts. In the central West are preserved many lines of moraine, with kettle-holes, kames and drumlins which mark successive pauses in the retreat. An interesting episode of later glacial times was the formation in Minnesota and Manitoba of a great body of fresh water, Lake Agassiz, which was 700 miles long from north to south. In the Great Basin, the Pleistocene was a time of far less arid climate than at present. In the eastern part of the Basin was established the great Lake Bonneville, which had an outlet north into Snake River.

If we consider these facts proved, then the only glaciation which could *materially affect the distribution of our boreal societies is that* of the *last,* or Wisconsin epoch. Through the work of Chamberlain, Leverett, Salisbury, Upham and others, the limits of this ice invasion have been definitely mapped. According to Chamberlain, the climatic conditions prevailing about the margin were intermediate between those of Greenland and Alaska at the

present time. In the former place the vegetation is sparse and of the tundra type [1]), in the latter, the forest occurs on the stagnant ice margin, for the forest covering the greater part of the lowlands near the Malaspina Glacier at the base of Mt. St. Elias extends up over the moraine and thence over the surface of the glacier covered with morainic material for four or five miles [2]). The vegetation, thus found on the glacier itself, consists principally of alders (*Alnus oregana*) growing to a height of 20 to 30 feet, but on the outer or older portion of the moraine, there are dense groves of spruces (*Picea sitchensis*), mixed with cottonwood (*Populus balsamifera*) and an undergrowth of salmonberry (*Rubus spectabilis*), devil's club *Fatsia* (*Echinopanax*) *horrida*, ferns and huckleberry bushes (*Vaccinium ovalifolium?*). It would appear that the glaciers would not affect the tree distribution at any great distance from the ice front. Before considering this point in detail, let us describe the tundra and bog conditions of these times, because, such associations of species as one finds in the bogs and tundra of today occupied the strip of country between the edge of the ice sheet on the one hand and the northern edge of the forest vegetation on the other.

Since bog associations of plants may occupy under favorable conditions other habitats than undrained depressions, they probably existed on the borders of the heavily loaded streams, in ravines and moist situations generally along the ice front. It is to be noted, that practically all of the existing small lake areas of the northern states were covered by the ice during the maximum extension of the Wisconsin ice sheet. As there is no reason to believe that the drift sheets of the preceding epochs, which in many places extend beyond the Wisconsin terminal moraine, contained such small undrained depressions, it follows that the bog societies must have occupied the habitats.

Many glacial plants other than bog plants, such as *Silene acaulis*, *Diapensia lapponica*, *Oxyria digyna*, *Loiseleuria procumbens*, etc. occupied dry land situations on the moraines, on the exposed and worn rock boulders [3]), or in the sand along the edge of the streams, that rushed out beneath the glacial ice. Many of these plants, however, survived in the glacial covered country, as is evidenced by the fact, that flowering plants of many species have been collected in the short arctic summer, as far north, as the land areas of North

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1) TRANSEAU, E. N.: On the geographical distribution and ecological Relations of the bog plant Societies of North America. Botanical Gazette XXXVI: 401—420 Dec. 1903; JEROSCH, MARIE Ch.: Geschichte und Herkunft der Schweizerischen Alpenflora. 1903, pp. 31—57; COLEMAN, A. P.: Glacial and interglacial Beds near Toronto. Journ. Geol. IX: 285: 1901; PENHALLOW, D. P.: The pleistocene Flora of the Don Valley, Report British Association Advancement Science 1900: 334.

2) RUSSELL, I. C.: Thirteenth Annual Report U. S. Geological Survey 1891—1892, pp. 19—21; Glaciers of North America. 1901.

3) See Fig. 1 of plate II: *Diapensia lapponica* on the top of the Adirondacks, Mt. Tahawus 1630 m. — Fig. 2 shows in *Cornus canadensis* a subglacial type occupying the uppermost forest region.

Diapensia lapponica L.
on summit of Mt. Tahawus, 5000 feet, Adirondack Mountains.
Photograph by Dr. Chas. H. Shaw.

Cornus canadensis L. (bunchberry)
growing in the Adirondack Mountain forests.
Photograph by Dr. Chas. H. Shaw.

America extend. Some of these plants grow on the moraines over the glacial ice itself others along the shore line within touch of the glacial ice. The nunataks, or tops of hills and mountains projecting above the Greenland ice sheet have their summer greenery and flowers [1]). For example on JENSEN's nunataks, a cluster of rocky peaks rising 100 to 500 feet above the inland ice, at a distance of nearly 50 miles back from the sea, KORNERUP, the geologist and botanist of Lieutenant JENSEN's party in 1878 collected 27 species of flowering plants. The ice surface there is 4,900 to 5,150 feet, or nearly one mile above the sea; and the nunatak summits vary in height from 5,200 to 5,650 feet. This very high and isolated flora comprised an abundance of *Luzula hyperborea*, *Carex nardina*, *Trisetum subspicatum*, *Poa trichophylla*, *Oxyria digyna*, *Cerastium alpinum*, *Saxifraga oppositifolia*, *Campanula uniflora*, *Potentilla nivea*, *Ranunculus pygmaeus*, *Silene acaulis*, *Cassiope hypnoides*, *Armeria sibirica*, and *Papaver nudicaule*. Dr. RINK found in Umanak Fjord near latitude 71° 40′ north at an elevation of 4,500 feet among numerous hillocks of ice and snow the following plants: *Papaver nudicaule*, *Potentilla nivea*, *Saxifraga tricuspidata*, *S. oppositifolia*, *S. caespitosa*, *Arenaria verna*, *Silene acaulis*, *Draba hirta*, *Diarrhena americana* and *Carex nardina*.

We can picture to ourselves the distribution of the glacial plants during the great ice age. In eastern North America during the maximum glaciation, all of the mountain tops of New England and Canada, New York and Pennsylvania were covered with glacial ice down to the great terminal moraine in northern New Jersey and Pennsylvania except the summit of Mounts Washington, Katahdin and perhaps the highest peaks of the Adirondacks. These peaks supported an assortment of arctic plants and many of these found today as relicts on them, such as, *Ledum latifolium* (= *L. groenlandicum*), *Rhododendron lapponicum*, *Diapensia lapponica*, *Salix uva-ursi*, *Nabalus nanus*, *Nabalus Boottii*, *Solidago alpestris* (= *S. virga-aurea*), *Sibbaldia procumbens* (= *Potentilla Sibbaldii*), *Silene acaulis*, *Arnica Chamissonis*, *Cassiope hypnoides*, *Bryanthus taxifolius*, *Loiseleuria procumbens*, *Oxyria digyna*, *Salix phylicifolia*, *Salix herbacea*, *Phleum alpinum*, *Lycopodium selago*, and others. The mountains of the west, the Rocky and Sierra Nevada systems rise in many peaks above an elevation of ten thousand feet. During the glacial period, south of the limit of the great ice sheet, they supported many large and important local valley glaciers which descended in many places nearly, or quite, to sea-level and the remnants of these vast ice fields are witness of the changes that have taken place in the glacial conditions of the Sierra from the time of the greatest extension of the snow and ice. A general exploration of this instructive region shows that to the north of California, through Oregon, and Washington, groups of active glaciers still exist on all the high volcanic cones of the Cascade Range, Mount Pitt, the Three Sisters, Mounts Jefferson, Hood, St. Helens, Adams, Rainier, Baker and others. But

1) WRIGHT and UPHAM: Greenland Icefields and Life in the North Atlantic 1896: 197—198.

the steeper slopes and many of the exposed rock faces then, as now, in the Rocky Mountains of the United States and Canada, the Selkirks and in the Sierras supported a rich and varied glacial flora which subject to the diverse environmental conditions entered a period of mutation with the evolution of many new forms. Many glacial plants also exterminated from Europe and the eastern United States where the conditions brought on by the increase of temperature, decrease of precipitation and increase of the dryness of the air were inimic to such alpine species, persisted under the more favorable and more diversified physical and climatic environment of the mountains masses of western and eastern America. The fact that nearly every requirement of a glacial plants is met in the physiographic constitution of the New England, eastern Canadian and cordilleran system of mountains together with the diverse character of the soils is an explanation of the richness of the alpine flora on the high mountains of the east and of the west.

On all mountain ranges which reached above snow line, there might be a periodic increase and decrease of snow, and when there were extensive areas of plateau at about the same level, the lowering of the snow-line might cause such an accumulation of snow as to produce great glaciers and ice fields. But along with such depression of the line of perpetual snow, there would be a corresponding depression of alpine and sub-alpine belts suitable for the growth of an arctic and temperate vegetation, and what is perhaps more important, the depression would necessarily produce a great extension of the areas of these belts on all high mountains, because, as we descend the average slopes become less abrupt, thus affording a number of new stations for such temperate plants as might first reach them. But just above and below the snow line is the area of most powerful disintegration and denudation, from the alternate action of frost and sun, of ice and water; and thus the more extended area would be subject to the constant occurrence of land-slips, bergfalls, and floods, with their accompanying accumulation of debris and of alluvial soil, affording innumerable stations in which solitary wind or bird borne seeds might germinate and establish themselves.

In fact, FERNALD [1]) has shown that the glacial till which was characteristic of the glacial front consisted of an extremely fine, mixed soil derived from rocks of very different kinds and it was probably the availability in these soils of the potassium, calcium and magnesium which made it possible for arctic-alpine plants, now confined to soils derived from rocks containing each of these elements specifically on all of our high mountains to grow side by side on the bogs, meadows and alluvial plains in front of the great continental ice sheet. Consequently the distribution of such plants, as *Dryas Drummondii* found on the Rocky Mountains and the GASPÉ Peninsula, 2000 miles apart, and *Festuca altaica*, a common grass on Mt. Albert, also found along the Yukon River and the mountains of Asia is explained by this continuity of soil habitat

1) Soil Preferences of Alpine Plants Rhodora IX: 191.

during the glacial period but which was subsequently interrupted by later changes, confining the arctic-alpine species to those habitats, even if far removed from each other, which possess a soil derived from rocks of a similar chemic constitution.

## 4. The Flora of the Rocky Mountains and of the Sierra Nevada.

During that extensive glaciation of the northern hemisphere and local glaciations in the southern, these elevations and depressions of the snow-line on all mountain ranges would have been at a maximum. At the present time, the only unbroken chain of mountains and highlands, connecting the arctic and north temperate with the antarctic lands, is to be found in the American continent, the only break of importance being in the neighborhood of the Isthmus of Panama, where there is a distance of about 300 miles occupied by rugged forest clad hills, between the lofty peaks of Veragua and the northern extremity of the Andes in New Granada. We should accordingly expect that this great continuous mountain-chain has formed the most effective agent in aiding the southward migration of the arctic and north temperate vegetation, which occurred during the period, or after the period of maximum glaciation, when as before mentioned, suitable conditions were found on the high mountains for their spread. We do find in fact, not only that a large number of northern genera and many species are scattered along this route, but at end of the long journey, in southern Chili and Fuegia they are found in numbers sufficient to form an element in the flora of those countries.

The alpine regions of the Rocky Mountains support an important number of endemic forms of plants which are related to species of the arctic alpine flora and in part to species which occur in the plains below. So *Gentiana Newberryi* stands near *G. glauca* and *G. frigida*, which are found in the Rocky mountains and in Siberia. *Astragalus oroboides* (= *Phaca elegans*) shows close affinities with *Astragalus alpinus* (= *Phaca astragalina*), *Dryas Drummondii* to *Dryas octopetala*. The question naturally arises: have these endemic forms been evolved as new species out of arctic-alpine forms since their migration along the Rocky Mountains, or do they represent in part the relicts of a former arctic-alpine vegetation, the congeners of which have disappeared except on the mountain summits of the west? To satisfactorily answer these questions, the following table of the alpine dicotyledonous plants of the Rocky Mountains is given.

A horizontal line (—) before the name indicates that the plant occurs also in Asia, a line (—) after the name that the plant occurs in Greenland and eastern North America, while a vertical line (I) before the name indicates that the species is only present in the arctic regions of America, and with Eu., that it is present also in the European mountains, Scandinavia, Iceland. The southern limit of each species is given by citing the latitude beyond which it does not apparently extend.

The first list is based upon a manuscript list of plants submitted to Prof. O. DRUDE in a letter from FR. BRENDEL, dated Peoria, Illinois, January 4, 1888; ENGLER, A., Entwickelungsgeschichte, pp. 150—151; RYDBERG, P. A., Flora of Montana and Yellowstone Park, 1900;

RYDBERG, P. A., Flora of Colorado 1906; FARR, EDITH M.: Catalogue of the Flora of the Canadian Rocky Mountains and the Selkirk Range 1907. The representative species selected from these publications to display the alpine floras of the Rocky Mountains and the Sierra Nevada Mountains have been compared with WARMING, Oversigt over Grønlands, Islands og Faerøernes Flora 1887, Videnskab Meddel. fra den naturh. Forening Kjøbenhavn 1887: 236—304; KJELLMAN, *Asiatiska Beringssunds-Fanerogamflora in Vega Expedit. Vetensk. Arbeiten* pp. 475—497. The list is not intended to be complete. See for more complete details, as to the alpine species of the Rocky Mountains, the lists included in Part IV, Rocky Mountain Region. The second list, also not complete, is based on WATSON's Botany of California; COVILLE, F. V., Botany of the Death Valley Expedition 1893; MERRIAM, C. HART: Results of a biological Survey of Mount Shasta, California 1899 and ENGLER's Entwicklungsgeschichte, pp. 152—154. For more complete details consult Part IV. California Region, Sierra Nevadan District.

Eu. — *Anemone narcissiflora* L.
» *globosa* Nutt.
1 — *Ranunculus Cymbalaria* Pursh.
» *adoneus* A. Gray.
» *ovalis* Raf. (*R. rhomboideus* Goldie).
Eu. 1 » *pygmaeus* Wahlb.
1 » *Eschscholtzii* Schlecht. (*R. nivalis* R. Br.).
*Aquilegia caerulea* James.
*Caltha leptosepala* DC.
*Delphinium pauciflorum* Nutt. (*D. Menziesii* DC.).
*Arabis canescens* Nutt.
» *furcata* Wats.
*Cardamine Leibergii* Holz.
*Vesicaria alpina* Nutt. (*Lesquerella alpina* Nutt.).
1 *Draba glacialis* Adams 52°.
» *oligosperma* Hook.
» *densifolia* Nutt.
Eu. — » *hirta* L.
» *streptocarpa* A. Gray.
» *laevipes* DC. 52° (*D. tomentosa* Clairv.).
» *crassifolia* Graham 42°.
Eu. 1 » *incana* L.
» *chrysantha* S. Wats.
» *aurea* Vahl.
Eu. 1 » *nemoralis* Ehrh. (*D. nemorosa* L.).
1 *Hutchinsia (Smelowskia) calycina* Desv. 52°.

*Parnassia parviflora* DC.
Eu. — *Alsine (Arenaria) verna* L. — 52°.
1 *Arenaria (Alsinopsis) propinqua* Richards (*A. verna* L. var. *hirta* Wats.).
1 » *(Alsinopsis) Rossii* R. Br. 54° (*A. stricta* Michx.).
» *Fendleri* A. Gray.
Eu. — *Silene acaulis* L. 40°. —
*Trifolium nanum* Torr.
» *dasyphyllum* Torr. & Gray.
» *Parryi* A. Gray.
*Oxytropis foliolosus* Hook.
» *multiceps* Nutt.
*Phaca (Atelophragma) elegans* Hook. (*A. oroboides americana* A. Gray).
*Homalobus tenuifolius* Nutt.
Eu. — *Dryas octopetala* L. — 41°.
» *Drummondii* Richards 52°.
— 1 *Geum Rossii* T. & G. 42°.
*Sieversia turbinata* Rydb.
Eu. — *Sibbaldia procumbens* L. 42°. —
*Horkelia Gordoni* Hook.
*Potentilla multisecta* Wats.
» *decurrens* Wats.
» *pinnatisecta* Wats.
» *diversifolia* Lehm. 52° (*P. dissecta* Pursh).
» *nana* Lehm. (*P. emarginata* Pursh).
Eu. 1 » *nivea* L. — 52°.
» *brevifolia* Nutt.
Eu. 1 *Rubus chamaemorus* L. — 52°.

Rubus nivalis Dougl.
Eu. — » arcticus L. —
Eu. Epilobium alpinum L. —
Ribes parvulum A. Gray.
Eu. — Sedum Rhodiola DC. 41° (Rhodiola rosea L.). —
» rhodanthum A. Gray.
Eu. — Saxifraga oppositifolia L. — 52°.
— » flagellaris Willd. — 41°.
— » bronchialis L.
Eu. 1 — » aizoides L. —
— » punctata L. 52°.
» Lyallii Engl.
Eu. 1 — » nivalis L. 41°. —
Eu. 1 — » cernua L. —
Eu. 1 — » rivularis L. —
Lithophragma (Tellima) tenella Nutt.
Mitella pentandra Hook.
» trifida Graham.
Eu. — Lonicera coerulea L. — 60°.
Eu. 1 — Linnaea borealis Gronov. —
Eu. 1 — Valeriana capitata (Pall.) Lk. 56°.
— Aster montanus R. Br. (A. sibiricus L.).
» apricus A. Gray.
Eu. — » alpinus L.
» andinus Nutt. 42°.
Oreastrum Haydeni Porter.
1 Erigeron compositus Pursh.
» melanocephalus A. Nels.
» radicatus Hook.
» leiomeris A. Gray.
» superbus Greene.
Eu. — » uniflorus (Hook.) L. —
» glabellus Nutt.
Eu. — » alpinus L.
» Coulteri Porter.
» leucotrichus Rydb.
1 » glabellus Nutt. 42°.
Diplopappus alpinus Nutt. (Aster scopulorum A. Gray).
Eu. — Solidago virga-aurea L. var. alpina Bigel. (S. alpestris Wald. & Kit.) — 54°.

Solidago nana Nutt.
Stenotus (Aplopappus) acaulis Nutt. (S. acaulis var. glabratus Eaton).
Aplopappus (Tonestus) pygmaeus Torr. & Gray.
» caespitosus Nutt.
» Lyallii A. Gray.
» (Oreochrysum) Parryi A. Gray.
Actinella (Rydbergia) grandiflora Torr. & Gray.
Balsamorrhiza incana Nutt.
» sagittata Pursh.
» Hookeri Nutt.
Tanacetum (Sphaeromeria) capitatum Torr. & Gray.
» Nuttallii Torr. & Gray.
Artemisia scopulorum A. Gray.
» spithamea Pursh.
— » frigida Willd.
Antennaria media Greene.
» aprica Greene.
» umbrinella Rydb.
Senecio triangularis Hook.
» Purshianus Nutt.
» carthamoides Greene.
» amplectens A. Gray.
» occidentalis Gray.
Tetradymia inermis Nutt.
Arnica Parryi A. Gray.
» longifolia D. C. Eat.
1 » Chamissonis Less.
» monocephala Rydb.
» fulgens Pursh.
Eu. — Saussurea alpina DC.
Hieracium gracile Hook.
— Crepis nana Richard.
Macrorrhynchus troximoides Torr. & Gray (Troximon [Agoseris] aurantiacum Hook.).
1 Campanula lasiocarpa Cham.
Eu. — » uniflora L.
1 Vaccinium caespitosum Michx.

Eu. — Arctostaphylus alpina Spreng. —
1 Cassiope Mertensiana Bong.
Eu. — » tetragona L.
1 Bryanthus (Phyllodoce) empetriformis Gray 42°.
1 » (Phyllodoce) glanduliflorus Gray 49°.
Eu. — Rhododendron lapponicum L. —
Dodecatheon pauciflorum Durand.
Eu. — Primula farinosa L.
» mistassinica Michx.
» angustifolia Torr.
» Parryi Gray.
Douglasia nivalis Lindl.
» montana Gray.
Eu. — Androsace chamaejasme Host.
— » filiformis Retz.
Gentiana (Anthopogon) barbellata Engelm.
Eu. — » tenella A. Gray (Amarella monantha A. Nels.). —
» propinqua Richards.
1 » arctophila Griseb.
Eu. » prostrata var. americana Hook. (Chondrophylia americana Engelm.).
— » glauca Pall.
Eu. — » frigida Hke. (Gray.)
1 » (Dasystephana) Romanzovii Ledb.
1 Gentiana (Dasystephana) Parryi Engelm.
1 » (Dasystephana) affinis Griseb.
Eu. 1 — Pleurogyne rotata Grsb. — 39°.
Eu. — Sweertia perennis L. (P. fontana A. Nels.).
Eritrichium arctioides DC.
Mertensia oblongifolia Hook.
1 » paniculata Ait. var. nivalis [Wats.
» alpina Torr.
» Parryi Rydb.
Pentstemon Hallii Gray.
» secundiflorus Benth.
» humilis Nutt.
» Harbourii Gray.
Chionophila Jamesii Benth.
Synthyris (Besseya) alpina Gray.
» plantaginea Benth.
Veronica Cusickii Gray.
Eu. — » alpina L. (V. Wormskjoldii R. & S.). —
Castilleia breviflora Gray (C. brachyantha Rydb.).
» occidentalis Torr.
» oreophila Greene.
1 Pedicularis (Elephantella) groenlandica Retz. —
» Parryi Gray.
» scopulorum Gray.
Eu. — » flammea L. —

This table shows that the endemic alpine plants are present in large numbers on the Rocky Mountains and that they are related to genera which occur at the foot of the mountains. Species which retreated and which existed during the Tertiary period in North America are not present now. Such plants as (to make a comparison with some European types of restricted distribution) *Dioscorea pyrenaica* and *Ramondia pyrenaica*, which may have originated in earlier periods and under suitable conditions persisted through the glacial period are sparingly present in the mountain flora. To this category also belongs in all probability *Douglasia nivalis*, *Bryanthus empetriformis*, *Bryanthus glanduliflorus* and *Chionophila Jamesii*. It may be stated in summation, that the endemic alpine flora of these mountains was in all probability first developed after the continental ice sheet had withdrawn itself.

For purposes of contrast, there is given a list of the alpine flora of the Sierra Nevada mountains. A comparison shows a becoming number of glacial plants with a greatly increased proportion of endemic species, than we find in the Rocky mountains. It is also noteworthy, that the alpine species of the Sierra Nevada mountains not only belong to genera which are represented by alpine species in the mountain system, but in addition genera occur in the Sierra alpine region not present in the Rocky mountains viz., *Lupinus*, *Claytonia*, *Calandrinia* and *Spiraea*. The signs affixed are the same as for the other table.

Ranunculus oxynotus Gray.
Aquilegia caerulea James.
— Aconitum Fischeri Rchb. (A. columbianum Nutt.).
Dielytra (Dicentra) uniflora Kellogg.
1 Draba Breweri Wats.
Arabis Lyallii Wats.
» platysperma Gray.
1 » Holböllii Hornem.
Streptanthus orbiculatus Greene.
» tortuosus Kellogg.
1 Erysimum asperum DC.
— Hutchinsia (Smelowskia) calycina Desv.
Viola blanda Willd.
» purpurea Kellogg.
» Beckwithii Torr. & Gray.
» Sheltoni Torr.
— Stellaria longipes Goldie.
» crispa C. & S.
Arenaria congesta Nutt.
» capillaris Poir.
» compacta Coville.
» pungens Nutt.
Calandrinia pygmaea Gray.
» nevadensis Gray.
Claytonia lanceolata Pursh.
Spraguea umbellata Torr.
Lewisia brachycarpa Engelm. (L. brachycalyx Engelm.).
Lupinus Andersoni Wats.
» *Covillei* Greene.
» albifrons Benth.
» ornatus Dougl.
Lupinus aridus Dougl. var. Lobbii Wats.
» Breweri Gray.
» Lyallii Gray.
Trifolium monanthum Gray.
Astragalus platytropis Gray.
» Whitneyi Gray.
» calycosus Torr.
» Austinae Gray.
» kentrophyta Gray var. elatus Wats.
Spiraea arbuscula Greene.
» discolor Pursh. var. dumosa.
1 Geum triflorum Pursh.
Potentilla dissecta Pursh.
» Wheeleri Wats.
— » gelida C. A. Meyer.
Eu. — » fruticosa L.
Eu. » *procumbens Sibth.*
» flabellifolia Hook.
Eu. — Sibbaldia procumbens L. (Potentilla Sibbaldi Hall.). —
Ivesia (Potentilla) Gordoni Torr. & Gray.
Pirus sambucifolia Cham. & Schlecht.
Amelanchier alnifolia Nutt.
Eu. — Saxifraga nivalis L. —
» bryophora Gray.
— » punctata L.
» Tolmiei Torr. & Gray.
Mitella Breweri Gray.
» pentandra Hook.
Heuchera rubescens Torr.
Ribes leptanthum Gray.

Ribes oxyacanthoides L.
» lacustre Pers. var. molle A. Gray.
» viscosissimum Pursh.
Eu. — Sedum Rhodiola DC. (Rh. rosea L.)
Epilobium obcordatum Gray.
Eu. » anagallidifolium Lam.
Eu. 1 — » alpinum L. —
Eu. — » origanifolium Lam. — (E. alsinifolium Vil.).
» clavatum Trelease.
Cymopterus cinerarius Gray.
» nevadensis Gray.
» terebinthinus T. & G.
Heracleum lanatum Michx.
Lonicera conjugialis Kellogg.
Aplopappus (Stenotus) acaulis Nutt.
» suffruticosus Gray.
» macronema Gray.
Bigelowia Bolanderi A. Gray.
Aster (Oreastrum) Andersoni A. Gray.
» adscendens Lindl.
» integrifolius Nutt.
» salsuginosus Richards.
Erigeron armerifolius Turcz.
» salsuginosus A. Gray.
» compositus Pursh.
Eu. — » uniflorus L.
» caespitosus Gray.
» inornatus A. Gray.
1 » ochroleucus Nutt.
1 Adenocaulon bicolor Hook.
Eu. 1 — Antennaria dioica L.
Eu. — » alpina L.
» media Greene R. Br.
Bahia integrifolia DC. (Eriophyllum caespitosum Doug.).
Hulsea algida Gray.
Chaenactis nevadensis Gray.
Helenium Hoopesii Gray.
Eu. — Artemisia norvegica Fries.
» Rothrockii A. Gray.

Artemisia arbuscula Nutt.
Senecio trigonophyllae Greene.
» canus Hook.
1 » lugens Richards.
Eu. — Arnica alpina Olin.
» Chamissonis Less.
» viscosa A. Gray.
» Merriami Greene.
» longifolia D. C. Eaton.
Raillardella argentea Gray.
Troximon glaucum Nutt.
1 Apargidium boreale Torr. & Gray (Leontodon borealis DC.).
Hieracium Breweri Gray (H. horridum Fries).
» albiflorum Hook.
» gracile Hook.
Campanula Wilkinsiana Greene.
Vaccinium microphyllum Hook.
» occidentale Gray.
1 Cassiope Mertensiana Bong.
Bryanthus Breweri Gray.
Kalmia glauca L. Ait. var. microphylla.
Ledum glandulosum Nutt.
Primula suffrutescens Gray.
Gentiana simplex Gray.
» serrata Gunner var. holopetala A. Gray.
» Newberryi Gray.
Phlox caespitosa Nutt.
» Douglasii Hook.
Gilia congesta Hook.
» Nuttallii A. Gray.
Eu. — Polemonium caeruleum L.
1 » pulchellum Bunge.
» confertum Gray.
Eritrichium (Krynitzkia) glomeratum DC.
» (Krynitzkia) fulvocanescens Gray.
Pentstemon Menziesii Hook.
» glaber Pursh.
» gracilentus Gray.

Pentstemon Roezli Regel.
» Newberryi A. Gray.
Mimulus implexus Greene.
» primuloides Benth.
Eu. — Veronica alpina L. —
» Cusickii A. Gray.
Castilleia affinis H. & A.
» miniata Dougl.
Orthocarpus pilosus Wats.
Pedicularis attollens Gray.
» semibarbata Gray.
Monardella odoratissima Benth.

## 5. The Vegetation Zones south of the Land Ice.

Down off the mountains during the glacial period existed glacial plants which formed bog and dryland associations, as previously mentioned. These with numerous sedges and grasses formed the tundra vegetation which skirted the southern edge of the great continental ice field. During the maximum glaciation, many plants were distributed only in the eastern part of North America. The following widely spread arctic-alpine species occupied Greenland, Labrador and the White Mountains and did not occur in the Rocky Mountains. *Thalictrum alpinum*, *Arabis alpina*, *Arabis stricta*, *Draba frigida* (= *D. tomentosa*), *Lychnis alpina*, *Alsine stricta* (= *Arenaria lapponica*), *Arenaria ciliata*, *Cerastium trigynum*, *Potentilla alpestris* (= *P. aurea*), *Alchemilla alpina*, *Epilobium origanifolium*, *Saxifraga aizoon*, *S. adscendens*, *Bupleurum ranunculoides*, *Gnaphalium supinum*, *Aronicum Clusii* (= *Doronicum hirsutum*), *Hieracium alpinum*, *Hieracium prenanthoides*, *Gentiana nivalis*, *Veronica saxatilis* (= *V. fruticulosa*), *Bartsia alpina*, *Pedicularis sudetica*, *Salix phylicifolia*, *S. arbuscula* [1]).

South of this existed in all probability a coniferous forest and immediately south of the conifers without any sharp demarcation a forest of broad-leaved trees. It would appear, then, that the glaciers did not effect the true distribution at any great distance from the ice front. The conifers probably came to occupy the outer rim of tree vegetation during the glacial period on account of edaphic factors suitable to their rapid spread. As we may learn from their present distribution, a youthful topography in which erosion is active, a high elevation and porous soil, all of which imply great variations in temperature and relative humidity, are more favorable to conifers than to broad-leaved deciduous trees.

The mixed forest to which we have referred, as occurring south of the arctic tundra vegetation, was a remnant of the great tertiary forest. This forest persisted during the period of refrigeration with its greatest denseness in the region drained by the Tennessee River and its tributaries. One tongue of this forest of less denseness probably reached in a northeastern direction, as far north, as a line following the windings of the west branch of the Susquehanna River to the Blue Ridge, thence along the Blue Ridge to the Schuylkill River, thence across to the southeast side of the Great Valley and following the hills on the south side of the Great Valley to the Delaware River.

1) ENGLER, A.: Versuch einer Entwicklungsgeschichte der Pflanzenwelt, 1. Teil; 148. 1879.

Arbitrarily considered, all of the territory above this line and between it and the great terminal moraine was a country influenced by the glacial cold where tundra conditions prevailed. All of the country south of it, protected by the Alleghany Mountains, was covered by a forest composed in the main of those species of trees, not destroyed by the glacial cold, that had existed in this region, and also in the far north, prior to the advent of the last glacial epoch. Comparing the northern remnant of the magnificent Tertiary forest with the southern remnant of this forest in the region drained by the Tennessee River and its tributaries and in the southern Appalachian Mountains, generally speaking, it lacked many of the peculiar arboreous and herbaceous species which characterize the flora of the south and many of which peculiar plants have their nearest living representatives in the flora of eastern China and Japan [1]).

*North Carolina.* These facts argue for a great antiquity of the flora of the mountains of western North Carolina. The presence of so many peculiar types of plants, not found elsewhere in America and having their closest relatives in eastern Asia, makes it more certain that groups, now broken up and detached, were once more continuous, and that fragmentary groups and isolated forms are but relics of wide-spread types, which have been preserved in a few localities where the physical conditions were especially favorable. This important principle is evidenced on every hand, as a botanist travels through western North Carolina [2]). The large size of the trees, the close commingling in a dense forest of a great variety of species, the graded-down appearance of the land surface, and the rounded contour of the mountains, all impress the fact upon him that the country through which he travels has been subjected through long ages to the continued action of climatic forces which have carved the land into its present form and influenced the character of the vegetal covering.

In the Ohio Valley, the streams flowing from the south during the glacial period would aid in preserving the broad-leaved mesophytes, as far north, as the Ohio River. It is probable that in the interior the Ohio basin was occupied by the oaks, ash, hickories, elms and maples. Judging by the present northern limits of some of these species it is doubtful if the conifers could compete with them at any great distance from the ice front, so that the belt of tundra and conifers may have extended, as far south, as the Ohio, but it seems probable that even north of this river species of oak, ash, elm and maple persisted [3]). Beyond the Mississippi, the conditions must have resembled those now prevalent in the Saskatchewan basin.

1) HARSHBERGER, J. W.: A phyto-geographic Sketch of extreme southeastern Pennsylvania Bulletin Torrey Botanical Club XXXI: 125—159. Mch. 1904.

2) HARSHBERGER, J. W.: An ecologic study of the Flora of mountainous North Carolina. Botanical Gazette XXXVI: 255. Oct. 1903.

3) BELL, ROBERT: The geographical Distribution of the forest Trees in Canada. Scottish Geographical Magazine XIII: 281. 1897.

*The Forest Flora in the Mountains.* The influence of the glaciers on the distribution of trees in the Rocky Mountains and the Sierra Nevada Mountains of California was most marked. Let us trace the history of the vegetation of this region before considering this point. We have already alluded to the extension of the sea which in the upper Cretaceous separated the western part of North America from the eastern. The Great Basin during the Lias was an enclosed natural lake, which was gradually filled by the action of aerial agents. Further during the early Cretaceous, the region of Missouri was covered by a sea and in Nebraska, there are evidences of a long continuance of a fresh-water lake. It is also probable, that the prairie region in the Miocene period was covered water. With the drying up of these seas and inland lakes, the prairie region was formed and the plant associations following the retreat of the water culminated in a prairie grass formation, which still further acted as an influence in the separation of the eastern and western floras. The factors mentioned above were sufficient to introduce a differentiation into the floras of the two widely separated regions and the separation of the tree vegetation of North America into eastern and western types may be said to have begun. That this separation was not fully accomplished until, after the Glacial period is proved by the presence of remains of *Sequoia* trees in the eastern United States of a later date. The climate of the eastern slopes of the Rocky Mountains during the upper Cretaceous period and subsequent must have been more humid than the climate of today, which is comparatively arid. We have proof of this climate in the petrified forests of Arizona, where the trunks of gigantic trees have been preserved unlike the flora of that region at the present day. In the soft shale rock at Florissant, Colorado are found fossil leaves, fruits and twigs of trees clearly allied to the living redwoods or sequoias of California, to oaks, hornbeams, alders, walnuts, chestnuts, elms, ashes, sumachs, hollies and other trees and shrubs arguing for a different climate in the far past.

The oncoming of the glacial period and consequent refrigeration produced even a more marked change in the distribution of tree vegetation than the inland sea of upper Cretaceous times. With the development of the continental glacier, as the ice sheets spread from the two great centers of accumulation, they united in the region north of lakes Superior and Huron. With their near approach to the lakes the area of conifers was divided into an eastern and western section. The trees of the western section were submitted to the action of the local mountain glaciers and their areas of distribution were thus broken up and many of the species of eastern affinity were destroyed and others were restricted within narrow limits. This has not been worked out for all the species of western trees, but the principles may be illustrated by a discussion of the glacial and post glacial distribution. Of the giant trees of California *Sequoia gigantea* (= *S. Washingtoniana*) JOHN MUIR[1]) observed that the location

1) MUIR, JOHN: On the post-glacial History of Sequoia gigantea. Proceedings American Association for Advancement Science 1876: 242—253.

of the *Sequoia* forests was on the general forest soil-belt between the individual Sierra mountain glaciers. The remarkable gap between the northern and southern groves is located exactly in the pathway of the vast mer de glace of the San Joaquin and King's River basins. The other great gap in the belt, forty miles wide, extending between the Calaveras and Tuolumne groves, occurs exactly in the pathway of the great mer de glace of the Tuolumne and Stanislaus basins, and that the smaller gap between the Merced and Mariposa groves occur in the pathway of the Merced glacier. We are, therefore, forced to conclude that the *Sequoia* trees which were widespread in Miocene times were restricted by the action of the glacial ice to the California side of the continent and that the remnant of a once continuous forest was still further separated into isolated groves by the action of local glaciers, such as filled the basins of the San Joaquin, Tuolumne and Merced rivers. The action of the glaciers on the distribution of other forest trees, illustrated by this clear cut example, must have been similar and we have as a result the separation of the original forest of North America into the Atlantic and Pacific types. A comparison of the coniferous vegetation of the Rocky Mountains, of eastern North America and of the Pacific coast is to be found afterwards (Chapter IV). A similar difference shows itself in a comparison of the broad-leaved vegetation of eastern and western North America. When during the glacial period, the greater part of North America was covered with ice and later submerged in its central plain region beneath the sea, it is not strange that the peculiarities of the western and eastern floras manifested, as far back, as Cretaceous times should be further accentuated. Many characteristic genera of the Atlantic slopes of North America are missing in California, and the prairie region, viz., *Asimina*, *Zanthoxylon*, *Stuartia*, *Gordonia*, *Tilia*, *Robinia*, *Gleditschia*, *Gymnocladus*, *Cladrastis*, *Nyssa*, *Liquidambar*, *Viburnum*, *Clethra*, *Ilex*, *Catalpa*, *Diospyros*, *Sassafras*, *Benzoin*, *Carya* (*Hicoria*), *Morus*, *Ulmus*, *Fagus*, *Castanea*, *Carpinus*, *Betula*, *Magnolia*, *Liriodendron*. There are lacking also many trees which from the Tertiary period to the present maintained themselves in North America. Common and related species of the following genera occur in eastern and western North America: *Aesculus*, *Acer*, *Rhamnus*, *Ceanothus*, *Ptelea*, *Euonymus*, *Acer*, *Negundo*, *Staphylea*, *Rhus*, *Sophora*, *Cercis*, *Prunus*, *Pirus*, *Crataegus*, *Amelanchier*, *Calycanthus*, *Philadelphus*, *Ribes*, *Cornus*, *Sambucus*, *Viburnum*, *Symphoricarpos*, *Lonicera*, *Cephalanthus*, *Gaultheria*, *Kalmia*, *Styrax*, *Fraxinus*, *Platanus*. On the other hand, the plants mentioned below are peculiar to western America: *Fremontia californica*, *Larrea mexicana*, *Cneoridium dumosum*, *Zizyphus Parryi*, *Karwinskia Humboldtiana*, *Adolphia californica*, *Glossopetalon nevadense*, *Prosopis*, *Parkinsonia* with two species, *Canotia holacantha*, *Charpentiera californica*, *Whipplea modesta*, *Menodora* with many species. That this separation took place during and subsequent to the glacial period is proved by the discovery in the Pliocene deposits of California of remains of *Platanus occidentalis* and species of *Magnolia*. LESQUEREUX [1]) has discovered at Golden

1) LESQUEREUX in Hayden Report 1872: 371—427.

**Sequoia gigantea** Dec.,

*Calaveras Big Tree Grove, Sierra Nevada, California.* Two trees on either side of path are known as "Professor Gray" and "Dr. Torrey." "Grizzly Giant" is in the background.

City Colorado two fossil species of *Platanus*, three of *Juglans*, one of *Ulmus*, one of *Lindera* (*Benzoin*), one of *Sapindus* and one of *Ficus*. None of these genera exist in Colorado at the present day.

*Prairies*. With the gradual disappearance of the sea which extended over the central prairie region during the Miocene period, the soil at first was largely impregnated with the salts of sea water, which were afterward leached out by the rain which with the drying up of the land fell with less constancy, producing more arid conditions on the eastern slopes of the Rocky Mountains. HARVEY [1]) suggests that on account of the low precipitation this region bounded on the west by the crest of the Rocky Mountains was denied at first to tree invasion and came to be occupied by a prairie formation, which was displaced after the glacial period by the invasion of trees, while the plains became grass-covered. The formation of the prairies introduced a drier climate in the interior of North America and new elements of plant life were introduced which developed into the numerous and peculiar forms, characteristic of the prairie region of today. Numerous Cactaceae, many Chenopodiaceae, the Chlorideae, the peculiar Polemoniaceae of the prairies appeared during Miocene and Pliocene times.

*Coast Plains*. We have thus far traced the developments of the main types of the North American flora during the Glacial period. Before treating of the post glacial and present distribution of North American plants, let us briefly allude to the conditions which probably existed on the Atlantic and Gulf coast plains.

During the Tertiary period that portion of North America which now comprises the Atlantic and Gulf coast plains was beneath the Atlantic Ocean. Later during the upper Tertiary, it was elevated excepting the portion comprising the Florida peninsula. With its appearance above the sea, it was tenanted from two main sources of plant supply, viz., the flora which covered the elevated mountain and table lands of the present eastern states as far north as New York and the coastal flora which must have been differentiated and fringed the tertiary sea coast composed of typic sea coast plants. The sandy plains of the coast were tenanted chiefly by pines which if they did not arise as coastal plain species probably were derived from the near, by tertiary forest so frequently referred to. The assortment of species in the newly formed land depended largely upon edaphic conditions. The sandy soil of the coastal plain would only support those species which had previously existed in the near by land areas under similar edaphic conditions, which may have been a rocky ledge of some mountain side, or the sandy bottom of some silt filled ravine, or which were sufficiently plastic, as species, to adapt themselves to the new surroundings.

*Colony of northern plants in Florida*. The topography of Florida in the neighborhood of the Appalachicola River is in striking contrast to the level

areas in other parts of Florida and the adjoining States. There are high river bluffs and deep ravines with steep slopes. In these ravines, and especially on the north facing slopes, is to be found a mesophytic association of plants that is abundant farther north, but which reaches its southern limit here. Among the plants of this association are beech, mapel (*Acer floridanum*), *Mitchella*, *Hepatica*, *Sanguinaria*, *Epigaea*, *Anemonella* (*Syndesmon*) and many other species that dominate in mesophytic northern woods. In this association one finds two of our most notable endemic plants-*Torreya* and *Croomia*[1]. They presumably are preserved here perhaps because of exceptionally favorable topographic conditions, while in other places which represent their distribution in the great Miocene forest they have become extinct because of unfavorable conditions.

*Contrast of Mountain and Coastal Floras.* The presence of the following on the Pocono plateau and the coastal plain is thus accounted for:

Woodwardia virginica L.
Lygodium palmatum Bernh.
Lycopodium inundatum L.
Eleocharis olivacea Torr.

Orontium aquaticum L.
Eriocaulon septangulare With.
Peltandra virginica L.
Pontederia cordata L.
Juncus pelocarpus E. Mey.
» militaris Bigel.
Aletris farinosa L.
Amianthium (Chrosperma) muscae-toxicum Walt.

Scirpus Torreyi Olney.
Scirpus subterminalis Torr.
Carex Collinsii Nutt.
Carex albolutescens Schwein (C. subulata Michx.).
Polygonum Careyi Olney.
Myriophyllum tenellum Bigel.
Rhexia virginica L.
Proserpinaca palustris L.
Limnanthemum lacunosum Vent.
Utricularia purpurea Walt.
» cornuta Michx.
Habenaria (Blephariglottis) blephariglottis Willd.

Originally developed as mountain or plateau forms, they spread down to the coastal plain, where by mutation they were augmented undoubtedly by new forms. After the ice sheet had moved off from the Pocono plateau, which suffered glaciation many of the old plateau forms returned from glaciated mountain crests to reclothe the table land left bare by the retreat of the glacial ice[2]. On the unglaciated mountain crests south of the terminal moraine of New Jersey, which represent a former peneplain, exist plants referred to above found in great numbers in sandy soil along the Atlantic coast. According to N. L. BRITTON the most noteworthy are *Juncus Greenii*, *Solidago puberula*, *Orontium aquaticum*, *Tephrosia* (*Cracca*) *virginiana*, *Lespedeza hirta*,

1) COWLES, H. C.: Colony of northern Plants along the Appalachicola River, Florida. Read at Eight International Geographic Congress, Sept. 10. 1904.

2) HARSHBERGER, J. W.: An ecologic Study of the Flora of mountainous North Carolina. Botanical Gazette XXXVI: 247 and 379.

*Lupinus perennis*, *Quercus ilicifolia* (= *Q. nana*), *Corema Conradii.* At Culver's Gap, Britton found *Polygala polygama*, *Lechea racemulosa*, all abundant in sandy soil along the coast. In all probability, therefore, the flora of the Kittatinny, or Shawangunk Mountains described above is peculiarly an endemic one showing relict endemism and that the flora of the pine barrens of the coast is a derived one. The same peculiar distribution is noticed in the southern states where on the high mountains above five thousand feet such plants occurring also on the sandy flats of the coastal plain are found, viz., *Zygadenus limanthoides*, *Xerophyllum asphodeloides*, *Amianthium* (*Chrosperma*) *muscaetoxicum*, *Leiophyllum* (*Dendrium*) *buxifolium*, and *Hudsonia montana* of Table Mountain related to *Hudsonia tomentosa* of the coast.

With reference to the coniferous vegetation previously mentioned, in this connection it is a noteworthy fact that the distribution of the long-leaf pine *Pinus palustris* in general coincides with the area of the Atlantic and Gulf coastal plains except on such mountains as Pine and Horseleg where it is found above 1000 feet. This is largely influenced by the fact that in its demands upon the soil this pine is to be counted among the most frugal, as far, as mineral constituents are concerned, if only the mechanical conditions which influence favorable soil moisture are not wanting. It thrives best on a light silicious soil, loamy sand, pebbles or light sandy loam with a slightly clayey subsoil sufficiently porous to insure at least a partial under drainage and to permit unimpeded development of the long tap root. The Cuban pine, *Pinus cubensis* (= *P. heterophylla* = *P. caribaea*) is confined to the coast plain of northern and central Florida and southeastern Georgia. The loblolly pine, *Pinus taeda* is a coastal plain species, while the pitch pine *Pinus rigida*, which occurs on the New Jersey coast and coastal plain is also a prominent tree on the mountain summits of northeastern Pennsylvania and elsewhere.

## Chapter III. Postglacial and Recent History of the North American Flora.

### 1. Immediate Effects of Glacial Retreat.

*Boreal Associations and Forests.* All of North America, north of the great terminal moraine, which marks the southern boundary of the continental ice sheet with the probable exception of the nunataks, unglaciated areas and parts of the Pacific coast has been tenanted by plants, which have migrated from several directions into the territory abandoned by the glacial ice. (See the arrows illustrating in the accompanying Figure 4 the directions of Plant Migration.) Geologists[1]) believe from evidence afforded by the time that it has taken for the river to cut its gorge at Niagara, that 15,000, to 25,000 years have elapsed

1) GILBERT, G. K.: *Niagara Falls and their History.* National Geographic Monographs, No. 1, Sept. 7. 1895. TARR, RALPH S.: The physical Geography of New York State 1902: 266—299.

since the close of the glacial period. If their deductions are sound, then certain elements of the flora of the northern part of America cannot be older than 25,000 years at the outside. Some of its elements may be much older and we have reason to believe that many boreal plants existed as such on the nunataks which were unglaciated areas above the sea of ice.

With the renewal of a milder climate and the consequent recession of the glaciers, the plant associations would gradually spread in the direction of continous habitats and generally northward. Several waves of plant migration may be recognized. The glacial element would follow the retreating edge of the ice to be followed by bog and tundra types which would then push into the barren ground left by the retreating ice. Many glacial plants, existing in the extremely fine and mixed soils, apparently rich in the availability of potassium, calcium and often magnesium derived from rocks of different kinds, would be left as relicts on such mountain peaks as Mt. Marcy, Mt. Washington and Mount Katahdin, or in circumscribed areas in the lowlands, such as the botanist finds in New Brunswick and Labrador. The determination of the postglacial habitat of each species of arctic-alpine plant was regulated by the soil preferences of that species. Whether the plant was to grow upon a soil derived from rocks containing potash, calcium or magnesium was a matter of specific preference. FERNALD (l. c.) divides the known localities where arctic-alpine plants are found into three main groups, corresponding with the character of the rocks from which the soils are derived. In the first group of alpine areas, he includes the White Mountains, the Adirondack Mountains, the highest summits of the Green Mountains of Vermont; Baldpate, Abraham, Saddleback, Bigelow, Katahdin and nearly all the other naked-topped mountains of Maine; the great table land of Table-top Mountain in Gaspé; and Mt. Desert Island and other exposed parts of the eastern coast of Maine. The predominant rocks are granite, or gneiss, and all are especially high in potassium which becomes the distinctive soil element of the alpine areas constituting our first group, where we find 122 plants, nearly two thirds of which in their alpine distribution are quite unknown on the mountains of the other groups. Such plants are *Hierochloë alpina*, *Salix phylicifolia*, *S. argyrocarpa*, *Cassiope hypnoides*, *Arenaria groenlandica* etc. The second group of alpine areas includes the cliffs of Percé, of the north coast of the Gaspé Peninsula, and of Bic, which are chiefly limestones, calcareous sandstones, limestone conglomerates, and calcareous slates; the northwestern escarpments of Table-top Mountain, where *Salix vestita*, *S. glauca*, *Saxifraga oppositifolia*, *S. Aizoon*, *S. aizoides* and *Primula mistassinica* abound are limestones; the river cliffs and ledges of many streams of eastern Quebec, northern New Brunswick and Maine characterized by *Asplenium viride*, *Woodsia alpina*, *W. glabella*, *Carex eburnea*, *Tofieldia glutinosa*, *Astragalus elegans*, *Hedysarum boreale* (= *H. americanum*), *Shepherdia canadensis*, *Primula mistassinica*, *Pinguicula vulgaris*, *Erigeron hyssopifolius* are chiefly limestones or limy slates; the famous cliffs at Willoughby are of impure limestone, and the soil of the cliffs in Smugglers Notch are

controlled by their lime content. On these calcareous cliffs and mountains occur 135 species, 94 of which are apparently unknown upon the little calcareous, but strongly potassic rocks (Group I). The third group of exposures consists of the tableland of Mt. Albert in Gaspé, where serpentine prevails as a soft rock consisting of hydrated magnesium silicate. — But the appearance of these plants on the various mountains is a differential matter. If we take Mount Washington as a mountain, the summit flora is older than that of the lower alpine slopes of the mountains above timber-line and, the flora of these slopes is in turn older than that of such gorges as Tuckerman's Ravine, Huntingdon Ravine and Great Gulf which probably supported local glaciers for many centuries after the great ice sheet had retreated from the Presidential range[1]. Mount Katahdin, 161 miles northeast of Mount Washington, has a less number of alpine plants than the other mountain and some geologists believe it to have been buried entirely beneath the glacial ice sheet, and the place of the boreal flora upon the retreat of the continental ice sheet encroached upon Mount Katahdin is determined largely by the physiography of the mountain. The glaciers occupying the various basins of the mountain retarded the vegetation of the mountain, but with a favorable opportunity the encroachment perhaps began from the south-west and west. This idea seems to be confirmed by the present distribution of the spruce and fir which ascends higher on this side. It seems probable that the Great Basin was the first tenanted on the eastern side and the North Basin opposed this migration a much longer time for the reason that this basin which presents a scene of desolation, was the seat of a local valley glacier which was perhaps the last to disappear. The area over which the bog plants spread in taking advantage of the numerous glacial lakes and streams must have been much more extensive even than that now occupied by them. In the smaller glacial depressions where absence of wave action would favor littoral vegetation, the bog plants would become firmly established. On the western and eastern sides of the glaciated area, the tundra would be closely followed by the coniferous forests, because of their preglacial location separated from each other by a treeless region.

These conifers and those forming a still younger element surrounded the bog associations which were thus trapped by the environing tree vegetation. As the lake filled with such plants as *Potamogeton natans*, *P. lucens*, *Nuphar* (*Nymphaea*) *advena*, *Nymphaea* (*Castalia*) *odorata*, fringed with a circumarea of sedges (*Dulichium arundinaceum*, *Scirpus*, *Carex*) grasses (*Phragmites communis*) and other plants (*Sarracenia purpurea*, *Typha latifolia*, *Menyanthes trifoliata*, *Cicuta bulbifera*, *Scheuchzeria palustris*, *Utricularia* (several species), and an outer circumarea of *Cassandra* (*Chamaedaphne*) *calyculata*, *Dryopteris* (*Nephrodium*) *thelypteris*, *Kalmia glauca*, *Ledum latifolium* (= *L.*

1) This assumption is true if Mount Washington was a nunatak and not covered by ice as some geologists and glacialists claim.

Fig. 4. Map illustrating original Centers of Plant Dispersal as determined by the glacial Conditions of the Continent.

Arrows illustrate directions of glacial and post glacial Plant Migration. K Kansan Stage of Glacier. In Illinoian Stage of ice advance. I Iowan Stage. SS Southern limit Wisconsin Stage. B Boreal Flora along front of Terminal Moraine. Ap. Dispersal Center of Deciduous Vegetation. W. Dispersal Center of Coniferous Forests of Pacific Coast. Pr. Dispersal Center of Prairie Vegetation. D. Dispersal Center of Desert Vegetation. T Dispersal Center of Tropic Vegetation. Pleistocene Bridge.

*groenlandicum*), *Rubus hispidus*, *Comarum palustre*, *Andromeda polifolia*, *Chiogenes hispidula*, *Vaccinium Oxycoccus*, *Eriophorum virginicum*, *Rhododendron Rhodora*, was gradually transformed into firmer ground. Such shrubs as *Cassandra* (*Chamaedaphne*) *calyculata*, *Vaccinium corymbosum*, *Azalea viscosa*, *Ilex verticillata*, *Rosa carolina*, *Pyrus arbutifolia*, *Nemopanthes fascicularis* and young trees, *Acer rubrum*, *Betula populifolia*, *Betula pumila*, *Picea nigra* (= *P. mariana*) and *Larix americana* (= *L. laricina*) began to smother out the typic bog plants. The area thus encroached upon culminated in a climax forest association. Such a sequence of events one can trace in the coniferous areas of Wisconsin, Minnesota, New York, northern Pennsylvania, the New England states and Canada [1]). As an evidence of the constant shifting of floral types in a region may be mentioned the conversion of a former sphagnum bog area into a salt marsh. PENHALLOW [2]) finds upon examination of the strata in a number of salt marshes on the New England coast that their history is as follows: first-sphagnum bogs existed and were subsequently invaded by sedges, *Cassandra* (*Chamaedaphne*) *calyculata* and finally the white pine, *Pinus strobus*. Suddenly by the disappearance of the sea barrier, the former bog areas were flooded with salt water and converted into, salt marshes. PENHALLOW calculates from the character of the plant remains that an indefinite period may be assigned to the formation of the bogs, but that the *Cassandra*-layer (4—5 inches) was formed in 50 years, the second peat layer with small white pine stumps in 200 years, the first peat zone with larger white pine trees in 70 years and the superimposed salt marshes 100 years to form, a period of 420 years after the bogs had been captured by vegetation other than sphagnum mosses.

The swamp plant associations of North America next concern us. As we know from numerous physiographic studies that have been made of glacial basins, many of the lakes were formerly much larger than at present. Some of them in early post glacial times had steep banks, which were unfavorable to the development of shore vegetation. But by the lowering of the water level consequent upon the cutting down of the outlet, the shore line at present is a gradually sloping one and supports a "drained swamp" flora. In other cases, irregular arms extending away from the main body of the lake and protected from wind and wave action, doubtless supported a bog vegetation during the tundra dominance. Since then they have been separated from the main lake by a lowering of the water level. To day we find in such cases the bog vegetation still persisting in the depressions which were formerly arms of the lake, while on the shore of the main body of water, which came to be swampy at a much later period, the so-called "drained swamp" flora occurs. The relation of these two distinct associations of plants seems to depend largely

1) This account is based upon the observations of the writer upon kettlehole bogs in the great terminal moraine of the Pocono plateau of northeastern Pennsylvania and of E. N. TRANSEAU l. c. in Michigan and North America generally.

2) Transact. of the R. Soc. of Canada ser. 3, I sect. 4: 13—45.

upon the time when the swamps came into existence as swamp habitats. If they have existed since the days of tundra conditions, they may show a bog flora today. If they are of recent origin, the plants will correspond to the normal swamp plants of the present conditions. We may say, that the chances of capturing newly exposed land areas at the present time are all in favor of the swamp plants, largely because of the greater production of seeds, more adequate means for seed dispersal and better adaptations to present climatic conditions [1]). In early postglacial times, however, the conditions were far different. The climate being more boreal in its character favored the bog plants so that, they became practically the only competitors for the low-ground situations.

The spreading northward of the coniferous trees, as the third great wave of vegetation, was much slower in the west than in the east, because the local glaciation lasted much longer in the west than in the east for many of the mountains there today are glaciated. However, the conifers of the southwest suffered a gradual destruction with the disappearance of the inland sea and the recession of the glaciers due to increase in temperature, as compared with the rainfall. It is possible that the rainfall in Nebraska was never any greater than at the present time, and trees, such as *Pinus ponderosa* var. *scopulorum*, found in the central part of Nebraska [2]), far removed from the main area of their occurrence, seem to indicate that with the decrease in transpiration accompanying decrease in temperature certain trees might have been more widely distributed during glacial times, which cannot live now in Nebraska under present conditions. The bog plant associations perished with the coniferous forests and their southwestern boundaries today correspond with that of the forest. The delay in the northward migration of the coniferous forests of the Rocky Mountains and of the Pacific coast incident to the presence of extensive glaciers, which poured their ice streams down into the valleys and on the Pacific coast into the ocean, established the difference which we find in the distribution of the forest trees in northern Canada (the Mackenzie Basin) and Alaska at the present day. The forests of central, most northern Canada, are of the Atlantic type consisting of such trees as black and white spruces, *Picea nigra* (= *P. mariana*), *P. alba* (= *P. canadensis*), balsam *Abies balsamea*, tamarack *Larix americana* (= *P. laricina*) canoe birch *Betula papyrifera*, balsam poplar *Populus balsamifera* and aspen *Populus tremuloides*, all trees of essentially eastern origin which migrated north after the retreat of the continental glaciers. In Alaska, the species which are capable of existing under the inclement conditions of Alaska, are eastern species ranging across the continent, including the canoe birch, balsam poplar, aspen and white spruce. These reach the Pacific coast at Cook Inlet and thus head off, so to

1) TRANSEAU, E. N.: On the geographic Distribution and geological relations of the bog plant Societies of North America. Botanical Gazette XXXVI: 407—420. Dec. 1903.

2) BESSEY, E. C.: The Forests and forest Trees of Nebraska. Annual Report Nebraska State Board Agriculture 1888: 93.

speak, the western conifers in their northwestward migration. FERNOW in explaining why the Pacific coast forest of Alaska (consisting in the main of a mixture of the tideland, or Sitka spruce *Picea sitchensis* and coast hemlock *Tsuga heterophylla*, to which may be added, near timber line and farther west on the lower levels, the beautiful but useless alpine hemlock *Tsuga Mertensiana*) does not cover Kadiak Island and the Alaskan peninsula farther west, neglects the facts which the writer has advanced above to explain the distribution of the two distinct forests of Alaska. He adduces the following conditions which doubtless have been strongly operative in checking the advance of the western and Pacific types of coniferous vegetation. To secure the extension of the coast forest, it is necessary that the winds should blow from the north and east from September to May, when the spruce and hemlock release their seed, and it should be dry in order to permit the cones to do so. The contrary usually happens: there is during these months a constant succession of southeast and south winds and the air is heavily charged with moisture [1]). For this reason, the spread of the Pacific coast forests has been retarded, while the Atlantic coast forest of the interior shut off from such winds by high mountains including the McKinley range, had a decided advantage and has at last reached the Pacific coast ahead of the other forest.

*Spread of Plants from Southeastern Center.* In eastern North America a large number of species came from the great forest in which broad-leaved trees and coniferous trees were intermixed the latter found especially perhaps during glacial times on the mountain tops, which had remained undisturbed in their original home. At the close of the long ice age these trees were in a plastic condition through the influence of the pressure of species and through the action of the physiographic vicissitudes to which these fictile forms were subjected. Many species, therefore, found in this remnant of the great Miocene forest (which covered eastern North America west of the coastal plain, east of the prairie region and south of a line stretching along the Ohio River northeastward to another line following the windings of the present west branch of the Susquehanna River to the Blue Ridge, thence along the Blue Ridge to the Schuylkill River, thence across to the southeast side of Great Valley, thence to the Delaware River, which at this point marked the eastern extension of the forest) found congenial conditions in the most extensive land areas north of the terminal moraine where the species which had preceded in the first three floral waves formed open ecologic formations, which permitted, therefore, new migrants to occupy the ground. An inspection of the forest maps to be found in the ninth volume of the Tenth Census Report, Forest Trees of North America, shows that the majority of trees, the geographic distribution of which is illustrated by the maps, proceeded from a territory which seems to center in the area of the present states of southern and central Pennsylvania, Maryland, West Virginia, Kentucky, Tennessee, western North Carolina, south-

1) FERNOW, B. E.: The Forests of Alaska. Forestry and Irrigation VIII: 66—70. Feb. 1902.

western Virginia, northern Georgia, Alabama, Mississippi. A study of these maps reveals an important fact, that the spread of the species from this common center has been in a series of more or less concentric waves. The map accompanying this book, shows the northern limit of many of the most important forest trees. The lines may be taken to represent the several distributional advances of trees from the south. Approximately the trees invaded the northern part of the continent in the order indicated by their present relative distribution. (See colored map of North America.) Those farthest north entered the glaciated country first, either singly, as a species, or by mass invasion of associated species and those farthest south advanced much more tardily. The order of the invasion depending upon the adaptability of the species and the mode of seed distribution was, therefore relatively, as follows:

**Wind Carried Seeds.**

1. Picea alba (= P. canadensis), farthest north.
2. Picea nigra (= P. mariana), farthest north.
3. Larix americana (= P. laricina).
4. Populus balsamifera.
5. Populus tremuloides.
6. Betula papyrifera.
7. Abies balsamea.
8. Pinus strobus.
9. Thuja occidentalis.
10. Ulmus americana.
11. Acer saccharum.
12. Tsuga canadensis.

**Animal Carried Seeds.**

13. Quercus rubra.
14. Fagus americana.
15. Quercus alba.
16. Castanea americana (= dentata).
17. Juglans nigra.

The species most successfully provided with means of distribution and most easily adjustable extended farthest from the original center after the glacial period, which circumscribed the area of the original extended forest of the Tertiary period. The map shows that the outer confines of any particular genus is usually occupied by a single species. Nearer the center, two species are found; still nearer, if the genus is a large one, three and still nearer, four, etc. The position of the various shades of green on the maps suggests the circles of impulse produced when a stone is thrown into water. Theoretically these waves spread in all directions, unless they meet with obstacles, when they are deflected. Similarly the maps suggest a series of distributional impulses, by which the various species of oaks, ashes, hickories, and chestnuts moved out from a parent forest of great density into the territory left bare by the retreat of the great ice sheet[1]). Clearly, therefore, the deciduous forest of eastern North America has been derived from that forest which reaches its greatest development in the mountainous region of western North Carolina.

1) HARSHBERGER, J. W.: An ecologic Study of the Flora of mountainous North Carolina. Botanical Gazette XXXVI: 241—258, 368—383. Oct. and Nov. 1903.

MAC MILLAN[1]) remarks on this point, with reference to the character of the Minnesota flora, that it has been shown that while the valley of the Minnesota is geographically central, it is by no means botanically central, but, on the contrary, strongly southern and eastern. BESSEY[2]) has shown that the trees and shrubs of Nebraska have come up the Missouri bottoms and spread from the southeastern corner of the state west and northwest. MASON states that the trees of Kansas show the same origin. ADAMS[3]) has demonstrated this clearly in a study of the faunal distribution of animals and in a cursory way with plants. BRAY alludes to the same eastern origin in speaking of the east Texas timber belt. "The further extension of this forest is checked near the Brazos River by the drier climate of the southwest. Here its vanguard is broken into straggling detachments, of which only the hardier push onward along the prairie stream ways or up the deeper canyons of the hills. It is a striking phenomenon, this breaking up and gradual dwindling away of so vast and vigorous a forest. Not only in Texas, but far to the north, through the Indian Territory, Kansas, Nebraska, and the Dakotas, the same thing may be seen. Like a vast wave that has rolled in upon a level beach, the Atlantic forest breaks upon the dry plains, halting, creeping forward, thinning out, and finally disappearing, except where, along a river course, it pushes far inland[4]). In line with this argument, the conclusions of TRANSEAU are apropos. Transeau recognizes four centers of distribution in eastern North America in which the complex of climatic factors is most favorable to the type of forest vegetation there at present localized. When we depart from such centers, we find the conditions more and more unfavorable to the four particular types of forest which are: (1) the *northeastern coniferous centering in the* St. Lawrence *basin* and corresponding with our St. Lawrence Great Lake Region (see colored map): (2) the deciduous forest centering in the lower Ohio basin and southern Appalachians (our Piedmont-Appalachian-Ozark Plateau Region); (3) the southwestern coniferous forest, centering in the south Atlantic and Gulf coastal plain (our Atlantic-Gulf Coastal Region); and the insular tropic forest in the southern part of Florida on the West Indies (our Bahaman Region). TRANSEAU[5]) believes, that the present limits of these centers (which implies that in these places the trees attain their best development) is due to the influence of present climatic factors, viz., temperature, relative humidity, wind velocity and rainfall which most powerfully influence plant growth. These factors can be expressed

1) MACMILLAN, CONWAY: The Metaspermae of the Minnesota Valley 1892: 758.

2) BESSEY, C. E.: The Forests and forest Trees of Nebraska. Annual Report State Board Agriculture 1899: 79—102.

3) ADAMS, CHAS. C.: Southeastern United States as a Center of geographical Distribution of Flora and Fauna. Biological Bulletin III: 115—129. 1902.

4) BRAY, WILLIAM C.: Forest Resources of Texas. Bulletin 47, Bureau of Forestry U. S. Department Agriculture 1904: 15.

5) TRANSEAU, E. N.: Forest Centers of eastern America. American Naturalist XXXIX: 875—889. Dec. 1905. With 6 maps.

comprehensively in the ratio of rainfall to evaporation, expressed in percentages which, if plotted on the map, says TRANSEAU, exhibit climatic centers which correspond in general with the centers of plant distribution.

To return to the bog plant associations previously mentioned, we must describe the envelopment of these by the species of the broad-leaved trees which, as we have just seen, were derived from a southeastern center. In the Ohio Valley, the northern fringe of this deciduous forest encompassed the bog societies which here existed along the most southern lobe of the great ice sheet. The oaks, hickories, maples, ashes andelms following the line of their specific habitat, the stream valleys, or the uplands, the sandy stretches left by glacial drainage, or the eskers, kames and drumlins surrounded the bog associations in their northward progression.

## 2. Evolution of Coastal and Southern Mountain Flora.

*Different Areas.* With the final elevation of the land along the Atlantic and Gulf shores of the North American continent, we have the evolution of the coastal plain which has passed through an interesting history since the beginning of Cretaceous times. A zone extending from the "fall line" representing the eastern edge of rocky desposits of Archean age has at times been dry-land, as it is now, and at times sea bottom. Along the advancing and receding coast, gravels have been piled by streams coming from the landward side and with them sands and clays have been deposited[1]. Now it is a great plain marked by few hills and slightly terraced with bluffs on the margins of flood plains. Near the coast and along the flood plains, extensive marshes are found. This irregular zone of marsh is clearly distinguished from the higher plain. A lower plain extends from the coastal marshes out to the sea for many miles, until at last shallow waters change into deep waters, and the bottom plunges down with steep declivity into the depths of the Atlantic.

This region, which may be divided into several well marked areas, viz., the northern Atlantic coastal plain, the southern Atlantic coastal plain and the Gulf coastal plain, shows some marked differences in the flora of the different areas. These differences will be emphasized in succeeding chapters of this work. Suffice it to say here that the flora of the coastal plain is comparatively recent, more recent than the latest submergence when the Columbia gravels were deposited, perhaps as late as Pleistocene times and the endemic species have been evolved by mutation or otherwise since the Pleistocene, while the other plants have been derived from other sources of supply, one of which, not mentioned previously, is the West Indian group of islands. Many plant associations are met with on the coastal plain and their development has followed the elevation of the land above sea-level. For example in New Jersey, where the most northern extension of the plain occurs, we have the pine barren

1 MACGEE, W. J.: The Lafayette Formation. Twelfth Annual Report U. S. Geological Survey 1890—1891. Part I, Geology, pp. 219—515.

formation, the sphagnum swamp formations, the salt-marsh formations of the sea strand[1]. Similarly Kearney for Ocracoke Island, North Carolina[2]) has emphasized the great diversity of the plant covering of that part of the country and for the Dismal Swamp region.

MOHR[3]) gives an exhaustive treatment of the flora of Alabama and in his treatise on the subject discussing the flora of the coastal plain proper emphasizes in his classification the diversification of the plant formations. The same great diversity of plant formations is noticeable, according to BRAY, in the forests of eastern Texas[4], who distinguishes swamps and bayou forests, chiefly

Fig. 5. Cypress Swamp Formation. Prominent trees of the foreground are *Taxodium distichum* and *Nyssa uniflora*. Pearl River, Mississippi.
(Arkansas-Louisiana District of the Atlantic-Gulf Coastal Region.)

1) HARSHBERGER, J. W.: An ecological Study of the New Jersey strand Flora. Proceedings Academy Natural Sciences of Philadelphia. Oct. 1900: 623—671. Additional Observations on the Strand Flora of New Jersey l. c. Oct. 1902: 642—669.

2) KEARNEY, THOMAS H.: The plant Covering of Ocracoke Island. Contributions from U. S. National Herbarium V, No. 5: 269. Report on a botanical Survey of the Dismal Swamp. Region. do. V, No. 6: 359.

3) MOHR, CHARLES: Plant Life of Alabama. Contributions from U. S. National Herbarium, Vol. VI, 1901: 110—133.

4) BRAY, WILLIAM L.: Forest Resources of Texas-Bulletin 47. Bureau of Forestry U. S. Department of Agriculture 1904: 15—16.

in the coastal plain, hardwood forests of the alluvial bottoms, the mixed loblolly and hardwood forest of the interior of the coast plain, the longleaf pine forests of the Fayette prairie and the hardwood and shortleaf pine forests of the lignitic belt.

*Examples of coastal Species.* A large part of the coastal plain flora was developed along the edge of the continent in rather restricted localities when the shore line was much more depressed than at present. The sea strand vegetation and salt marsh vegetation probably originated as such on the strand of the Tertiary continent. The distribution of the species of the genus *Taxodium* is an interesting test case. *Taxodium distichum* grew, as far north, as Greenland in Miocene times. Later its distribution was restricted to the coastal plain and Mexico where the Mexican tree, *T. mucronatum*, grows according to my observations at 5000 to 8000 feet respectively. On the Edwards Plateau in Texas, *T. distichum* reaches enormous size at the edge of deep hollows at altitudes from 1000 to 1750 feet above the sea, hundreds of miles west of the sea, hundreds of miles west of the great cypress swamps (Fig. 5.). In all probability then after the Lafayette formation had been deposited *Taxodium* migrated into the coastal plain from higher elevations and became differentiated into two species *T. distichum* and *T. imbricarium* [1]). The absence of any serious obstacle to plant migration from and to all parts of the eastern section of the continent is a noteworthy fact connected with the spread of plants into the coastal plain. Completely open on the east and west, the denizens of the highland found no hindrance in peopling the new land, after its rise above the water. The longleaf pine (*Pinus palustris* [2]), loblolly pine (*P. taeda*), etc. were probably prompt to seize upon the sandy, or gravelly soil of the coastal plain after it had been raised from the sea, first after the Lafayette period of submergence, later after the Columbia deposits had been formed and the formation of these deposits afford a valuble time index [3]). Geologists tell us that the coastal plain has been elevated unequally, part at a time. The land soonest elevated was probably at once tenanted with forest trees such as the long leaf pine with seeds easily disseminated by the wind. As each successive portion of the plain was elevated the pine forests would naturally spread. The same may be said of the other coastal species which without question entered a period of mutation with the opening up of a new land for their occupancy. Since this was written, confirmation of it has been found in the discovery by ROLAND M. HARPER [4]) of *Pinus palustris* at an elevation above 1000 feet on

1) For the distinction of these species and their habitats see two articles by HARPER, ROLAND M. Taxodium distichum and related species. Bulletin Torrey Botanical Club XXIX: 383—399; also Further Observations on Taxodium do. XXXII: 105.

2) The name *Pinus palustris* L. is in N. Am. more commonly used for the *Pinus australis* Michx. — CHAPMAN in his Flora of the Southern Un. States states: "*P. palustris* L., the prior but inappropriate name". (Drd.)

3) See the reference to the monograph of W. J. MACGEE noted above.

4) HARPER, R. M.: Some noteworthy Stations for Pinus palustris Torreya V: 60. April 1905.

Pine Mountain in northwest Georgia, also in Alabama on the southern slopes of Horseleg and Head mountains, while there are several other species such as *Quercus lyrata*, *Q. Michauxii*, *Magnolia glauca*, *Ilex glabra*, *Nyssa uniflora* with equally interesting distribution. On the southern slope of Pine Mountain on the other hand associated with *Pinus palustris* are *Pinus echinata*, *Andropogon scoparius*, *A. virginicus*, *Aletris farinosa*, *Quercus marylandica*, *Q. prinus*, *Tephrosia* (*Cracca*) *virginiana*, *Ceanothus americanus*, *Viola pedata*, *Eupatorium album*, *Chrysopsis graminifolia*, *Solidago odora*, *Sericocarpus linifolius*, *Silphium compositum*, *Helianthus divaricatus*, all but one two of which are common to the dry pine barrens of the coast plain.

The action of the several uplifts and depressions of the earth's surface was most profound upon the vegetation of this coastal plain. With every submergence of the lower portions of the region, the vegetation in the area of submergence was destroyed, or if existing on the higher grounds, was subjected to such extensive changes of level, as to highly modify its character and the distribution of the component species. We have, however, data on the origin of a number of the elements of the coastal plain flora which is here apropos. On the coastal plain of the southeastern North America we have the following species of the genus *Yucca*: *Yucca filamentosa* var. *vera*, *Yucca filamentosa* var. *concava*, *Yucca filamentosa* var. *bracteata*, *Yucca filamentosa* var. *patens*, *Yucca gloriosa*, *Yucca aloifolia*, *Yucca recurvifolia*, all ranging east of the Mississippi River. West of that river, we have along the Red River, *Yucca louisianensis*, *Yucca arkansana*, in southern Texas, *Yucca Schottii*. The Mexican tableland is perhaps the original home of the entire group of Yuccas and the eastern species have taken a sweep around the gulf coast with a possible reflex wave northwest into the Appalachians. *Yucca aloifolia* perhaps a derivative of the Central American *Y. elephantipes* reached the coastal plains through the West Indian islands, for according to TRELEASE it seems to have evolved there. It is possibly a later introduction than the other species, as it is found on the newer parts of the coastal plain, viz., the Mississippi delta and the sand dunes of eastern Florida and Georgia. The fact also that so many varieties of the species *filamentosa* are recognizable, favors the view which the writer has all along held that a plant entering new country and subjected to different conditions is likely to undergo mutation. These plants reached the coastal plain in post glacial times, or not earlier perhaps, than the late Tertiary period.

The strand plants of the delta of the Mississippi River [1]) some of them of tropic, or subtropic distribution are the following, the New World species being left unmarked, while the circumterrestrial are marked by an asterisk:

| | |
|---|---|
| Batis maritima L. | *Avicennia nitida Jacq. (= A. littoralis Boiss.) — |
| Canavalia obtusifolia DC. | |

1) LLOYD, FRANCIS E. and TRACY, S. M.: The insular Flora of Mississippi and Louisiana. Bulletin Torrey Botanical Club XXVIII: 61—101. March 1901.

*Ipomoea acetosaefolia R. & S.
* „ Pes-caprae L.
*Lithophila (Philoxerus) vermiculata L.
Chrysoma pauciflosculosa Michx.
Uniola paniculata L.
Iva imbricata Walt.
Lippia (Phyla) nodiflora L.
*Sesuvium portulacastrum L.
Sabal glabra Sarg. (= S. Adansonii Guerns).
Serenoa serrulata Hook. f. (= Sabal serrulata R. & S.)

The soil of the delta itself represents that of the most recent formations of the southern coastal region. The "passes" of the Mississippi River are broad channels of water separated from the waters of the Gulf by an irregular and frequently very narrow strip of land of river deposit. Enormous quantities of silt must be sorted and arranged by tidal and current action in the formation of perhaps the newest land of the continent. *Phragmites*, *Vigna* and *Spartina* form associations. *Phragmites* occupies the higher levels, *Spartina* makes dense matted growths in the swampy ground of the lower levels. *Vigna* clambers on the canes and forms an almost impenetrable thicket, while occasional trees of *Salix*, *Cissus bipinnata* and *Ampelopsis arborea* occur along the bank. The muck marsh islands about the mouth of the Mississippi are composed of a very fine black alluvium with surface low-lying and flat. The flora is limited to a few species usually in two associations. The grasses *Spartina patens*, *S. stricta* and *Distichlis maritima* (= *D. spicata*) form one association, while succulents *Batis maritima* of tropic distribution, *Salicornia Bigelovii* and *S. ambigua* form the other. *Avicennia nitida* also is found here. These muck islands may be converted into sand islands by receiving a supply of sand, which sometimes reaches a thickness enough to support *Xyris serotina*, *Utricularia subulata*, *Oldenlandia uniflora*, *Siphonychia* (*Odontonychia*) *corymbosa*, *Polypremum procumbens*, *Gratiola subulata* (= *Sophronanthe hispida*) and *Diodia virginiana*. The flora of these islands are just as old, as the soil deposits on which they are found, the muck marsh flora being perhaps much older, as a floristic element. If the sand of the sand islands becomes thin by drifting away, muck marsh conditions may be restored by the appearance of *Batis* and *Salicornia*.

The sand plain floristically has three leading types determined by the physiographic age of the land. The youngest is the sand spit, which is a low lying extent of sand, hot, brilliantly lighted, wind swept and sea inundated in heavy weather. *Mollugo verticillata*, *Panicum repens*, *P. halophilum*, *Iva imbricata*, *Serenoa serrulata*, *Scirpus americanus*, *Cyperus cylindricus*, *Diodia teres*, *Syntherisma fimbriatum*, *S. filiforme*, *Cenchrus incertus*, *C. tribuloides*, *Euphorbia* (*Chamaesyce*) *cordifolia* and *Physalis angustifolia* represent the floral covering of the basins, low dunes and level reaches of the sand spit plain. The second type of sand plain is the open grass plain covered with herbaceous plants and such grasses as *Chaetochloa magna*, *Uniola paniculata* and the slender vines *Vigna glabra*, *Clitoria mariana*, associated with *Chamaecrista littoralis*, *Gerardia purpurea* and *Croton maritimus* (= *C. punctatus*). The sand plain, however, culminates in the forests of *Pinus palustris* (= *P.*

*australis*), *P. taeda*, *Quercus geminata*, *Q. virens* (= *Q. virginiana*) with *Sabal glabra*, *Serenoa serrulata*, *Opuntia pes-corvi*, *Baldwinia multiflora*, *Breweria sp.*, which may be looked upon as a recent derivation from the mainland, where the species mentioned form part of the pine barren flora. The absence of epiphytic mainland plants *Polypodium polypodioides* (= *P. incanum*) and *Tillandsia usneoides* is noteworthy.

*Forest Element of the Plains.* The Atlantic and Gulf coast plains were covered by a forest of the same general character from Virginia through the Carolinas, Georgia, northern Florida, Alabama, Mississippi, Louisiana, and Arkansas to eastern Texas, where near the Brazos River, it is checked by the drier climate of the southwest. It is instructive to study it in Texas, where it meets three other floral elements, viz., the Mexican flora, the Rocky Mountain flora and the Great Plain flora. Here the vanguard of the coastal plain forest is broken into straggling detachments, of which only the hardier push onward along the prairie streamways or up the deeper canyons of the hills. "It is a striking phenomenon, this breaking up and gradual dwindling away of so vast and vigorous a forest [1]). Not only in Texas, but far to the north, through the Indian Territory, Kansas, Nebraska, and the Dakotas, the same thing may be seen. Like a vast wave that has rolled in upon a level beach, the Atlantic forest breaks upon the dry plains — halting, creeping forward, thinning out, and finally disappearing, except where along a river course, it pushes far inland". The swamps and bayou forest form one of the elements of this coast forest that reaches Texas and reaches northward into Arkansas, as far, as southeastern Missouri, *Taxodium distichum*, *Nyssa sylvatica*, *Q. nigra* (= *Quercus aquatica*, *Carya amara* (= *Hicoria minima*), *Liquidambar styraciflua*, *Fraxinus platycarpa*, *Magnolia glauca* and *Nyssa uniflora* are the more important trees of this type of forest. The relative representation of species varies greatly in different areas. In one place *Nyssa uniflora* (see Fig. 5, p. 213) is dominant, in another *Taxodium distichum*, in another *Carya amara*. The hardwood forests of the alluvial bottoms in Texas consists of nearly all the well known valuable trees of the Atlantic States. The oaks (*Quercus*) stand first in quantity and variety: *Quercus Michauxii*, *Q. macrocarpa*, *Q. lyrata*, *Q. alba*, *Q. rubra*, *Q. phellos* and *Q. nigra* (*aquatica*) associated with *Fraxinus americana*, *F. viridis*, *Carya* (*Hicoria*) *aquatica*, *Carya olivaeformis* (= *Hicoria pecan*), *Carya tomentosa* (= *Hicoria ovata*), *Nyssa sylvatica*, *Platanus occidentalis*, *Tilia americana*, *Acer dasycarpum* (= *A. saccharinum*), *Ostrya virginiana*, *Carpinus caroliniana* and *Maclura aurantiaca* (= *Toxylon pomiferum*) and *Juglans nigra*. On the rich loose bottom soil, the timber grows very large and the intermixture of species is ordinarily very complete.

At the Gulf, the coast plain in Texas is a grass covered prairie. Twenty miles inland tongues of forests are found projecting down to the Gulf along

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1) BRAY, WILLIAM L.: Forest Resources of Texas Bureau of Forestry U. S. Department of Agriculture, No. 47. 1904: 15.

the ridges. These tongues are the seaward extension of mixed forests of loblolly pine and hardwoods. A change to long leaf pine land takes place, where the Neocene formation meets the sands of the Eocene. The loblolly pine *Pinus taeda*, covers the sandy ridges of the Neocene formation, while the swampy flats grow a jungle of hardwood with some loblolly, climbing vines and palmetto thickets. The alluvial valleys are filled with hardwood trees. The longleaf pine area in Texas is shaped like a broad wedge thrust in between the loblolly pine at the south and the shortleaf at the north, and extends southwestward to the Trinity River, where the overlapping areas of loblolly and shortleaf form its western boundary [1]). It always grows on dry sands from necessity rather than preference for it finds refuge from the competition, which is generally too much for it on moister and better soils.

The shortleaf pine *Pinus mitis* (= *P. echinata*) and post oak forests occupy the Tertiary plain, a region of sand beds and underlying clays, the remnant of an ancient plain worn away by erosion, in which the streams have established wide drainage bottoms. It is on these uplands that the shortleaf pine and oak prevail. In Texas, as in the South Atlantic States, the live oak *Quercus virginiana* (= *Q. virens*) occurs on the coast plain, where westward toward the Neuces, it yields to the increasing aridity of climate, becoming a more stunted open growth spreading over the grass prairie, which become converted into woodland.

*Northward extension of Areas.* One fact is noteworthy in the study of the coastal plain flora and that is the tendency to a northward migration of plants. That tendency is clearly illustrated in the northward extension of the pine barren flora on Staten Island and Long Island. The soil of the islands is generally sandy, but is occasionally more firm, where the strata of clay approach and form the surface. The geologic formations to the south and southeast of a line drawn from a point below Long Branch to another near the head of Delaware Bay are Tertiary, while those to the north of it are Cretaceous. The Tertiary soils extend southward along the Atlantic Ocean to Florida and are occupied by a pine barren flora. On Staten Island, Cretaceous strata are exposed in its extreme southern portion. They doubtless extend over the entire southern and eastern sections, but are mostly covered by a layer of material of variable thickness derived from the glacial drift. On Long Island, the great terminal moraine occupied the position marked by a range of hills extending throughout its whole length at an average distance of ten miles from the Atlantic. South of these hills sandy plains prevail, the material composing them having been formed partly from the modified drift of the hills, partly from the underlying Cretaceous strata. Those species detected on the Cretaceous soils of Staten Island, south of the moraine, and, therefore, not on the drift, are thirty four in number.

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1) BRAY, W. L.: l. c.

Magnolia glauca (= M. virginiana).
Hudsonia ericoides.
Ascyrum crux-andreae (= A. hypericoides).
Arenaria squarrosa (= A. caroliniana).
Polygala lutea.
Tephrosia (Cracca) virginiana.
Desmodium (Meibomia) laevigatum.
Desmodium (Meibomia) viridiflorum.
Rubus cuneifolius.
Crataegus uniflora (= C. parvifolia).
Eupatorium rotundifolium.
Aster nemoralis.
Aster concolor.
Chrysopsis mariana.
Gnaphalium purpureum.
Gaylussacia dumosa.
Andromeda (Pieris) mariana.
Kalmia angustifolia.
*Ipomoea pandurata.*
Phlox subulata.
Asclepias obtusifolia.
Euphorbia ipecacuanhae.
Quercus marylandica (= nigra).
Q. prinoides.
Q. phellos.
Spiranthes (Gyrostachys) simplex.
Juncus scirpoides var. macrostemon.
Xyris flexuosa.
Cyperus cylindricus.
Stipa avenacea.
Glyceria (Panicularia) obtusa.
Panicum verrucosum.
Andropogon glomeratus (= macrourus).
Lycopodium inundatum var. Bigelovii.

Of these species the following four have been detected in Suffolk County, Long Island. *Desmodium (Meibomia) viridiflorum, Rubus cuneifolius, Ipomoea pandurata, Phlox subulata* with the addition of *sixteen species* not mentioned previously:

Drosera filiformis.
Ascyrum stans.
Eupatorium hyssopifolium.
E. leucolepis.
E. album.
Aster spectabilis.
Solidago puberula.
Chrysopsis falcata.
Helianthus angustifolius.
Coreopsis rosea.
Utricularia subulata.
Chamaecyparis (Cupressus) thyoides.
Juncus pelocarpus.
Xyris caroliniana.
Eleocharis melanocarpa.
Sporobolus serotinus.

Thus it appears that 34 of these characteristic pine barren plants grow in the southern part of Staten Island, and that 46 of them have been detected in Suffolk County, Long Island.

It would seem that these species have followed the two more recent geologic formations, throughout their whole extent along the Atlantic coast. Another fact which stands out prominently in this connection is that not a single one of the above mentioned plants, growing as we have seen along the edge of the glacial drift is native of Europe, but belongs to a true American flora, which had its origin in the southern part of the continent and migrated northward into Staten Island and Long Island at the close of the great ice age. In contrast to this fact, we have another one equally prominent and that is, that of the species of plants growing on the moraine and north of it about one-third are common to northern Europe and America. The flora north of the morainic lines clearly antedates in point of occupancy of the country the more southern and American pine barren flora, which migrated northward at a date subsequent to the migration of the flora with strong European affinity.

It would seem that the flora of the Delaware Valley and of the coastal strip between the pine barrens and the salt marshes in New Jersey was

developed subsequent to the post-Pensauken uplift of the New Jersey geologists [1]) which occurred prior to the glaciation of the northern hemisphere. During the Pensauken submergence of the New Jersey geologists [1]) which occurred prior to the glaciation of the northern hemisphere, New Jersey was depressed to such an extent as to drown the Delaware River at its lower end, allowing the sea to pass up its valley and over the peneplain which had been developed during the previous cycle of erosion, so that a broad sound was formed which connected Raritan Bay with Delaware Bay, forming an island covered perhaps with pine barren vegetation. The mouth of the Delaware River during the post-Pensauken uplift was transferred to Delaware Bay followed by a cycle of erosion which lasted until the ice of the last glacial epoch invaded the northern portion of the state. It was during the post-Pensauken uplift that the flora of the lower Delaware Valley and the coastal strip was probably developed, so that the New Jersey pine barrens became surrounded by a fringe of vegetation developed along similar lines in the coastal strip and along the east and west banks of the Delaware River.

*Pine barren Flora.* Another illustration of the historic factors instrumental in plant distribution and one connected with the development of the pine barren flora in general is afforded by the peculiar flora of the Kittatinny or Shawangunk Mountains of northwestern New Jersey. This mountain chain forms a wall of almost constant altitude, averaging over 1200 feet in height, along the eastern side of the Delaware River from Port Jervis to the Delaware Water Gap. Its summit and western slopes are composed of a coarse, or fine, very hard silicious conglomerate, or sandstone, with little soil but that derived from the limited disintegration of these rocks and it is, therefore, highly silicious. While the mountain sides were extensively glaciated, there is very little glacial drift on the ridge. On these mountains exist a number of plants which occur also in sandy soil along the Atlantic coast. Among the noteworthy species, according to N. L. BRITTON, are *Juncus Greenii*, *Solidago puberula*, *Orontium aquaticum*, *Tephrosia* (*Cracca*) *virginiana*, *Lespedeza hirta*, *Lupinus perennis*, *Quercus ilicifolia* (= *Q. nana*), *Corema Conradii*. At Culver's Gap were found by BRITTON, *Polygala polygama*, *Gerardia pedicularia*, *Lechea racemulosa*, all abundant along the coast and *Prunus pumila*. Another peculiarity is the substitution of *Pinus rigida* on the mountains for *Pinus strobus* of the surrounding country.

The reason for the somewhat remarkable similarity of the pine barren and summit mountain floras is usually attributed to the similarity of the soil on the mountains to that of the plains bordering the coast. It is probably true that the plants occupy these areas, because they have adapted themselves to growing in soils of silicious sands, but to say that the soil is the prime factor in their distribution is putting the case too strongly. It appears that the flora

1) Cf. SALISBURY, J. D.: The physical Geography of New Jersey, Geological Survey of New Jersey, IV.

of the mountains is an endemic one showing relict endemism, representing a survival of a pine barren flora which was extensively represented in Atlantic North America as a plain flora occupying the situations controlled by the same edaphic conditions. During the elevations of the coastal plain, it spread its boundaries over the newly raised land and on to the more level mountain summits, but during a subsequent depression Pensauken submergence) it was again destroyed on the coastal plain or circumscribed in its distribution to similar edaphic situations in the mountains where it persisted during the glacial period. With the post-Pensauken uplift the New Jersey coastal plain was again tenanted by pine barren plants, which after the retreat of the great continental ice sheet migrated to Staten and Long islands.

This peculiar pine-barren assemblage of species[1]) of the mountain floras of northeastern Pennsylvania and northern New Jersey forms an element in the flora of the Pocono plateau 2000 feet above sea level in Monroe County, Pennsylvania. The original vegetation of this plateau consisted of five elements, viz., the pine barren association of plants, consisting of a forest of pitch pine (*Pinus rigida*) with associated species which entered the region at the close of the glacial period and occupied the looser sand and boulder material of the slopes and sides of the great terminal moraine having been derived from the pine barren elements of the mountains previously described; following 2, the deciduous forest of oaks, ashes, tulip poplar and associates, which moved up the river valleys and clothed the slopes of the mountains and edges of the tableland; 3, the chestnut and black locust forest, which moved up the valleys from the Susquehanna River to Laurel Ridge; 4, a forest consisting of white pine, black spruce and hemlock, which migrated into the region along the crest and in the upper mountain stream valleys from the main Appalachian system, comprising that association of species found in the mountains of Virginia and southward at an elevation of three thousand feet and over. 5, the sphagnum-bog flora, as a relict flora, when more glacial conditions prevailed. In these bogs are preserved many glacial plants such as *Ledum latifolium* (= *L. groenlandicum*), *Scheuchzeria palustris*, *Rhododendron Rhodora*, *Kalmia glauca*, etc. With the destruction of the original forest consisting of species disposed in general, as above, the pine barren element consisting of *Quercus ilicifolia* (= *Q. nana*), *Pinus rigida*, *Gaylussacia resinosa*, *Vaccinium vacillans*, *Epigaea repens*, *Gaultheria procumbens*, *Rhododendron viscosum*, *Kalmia angustifolia*, *Amianthium* (*Chrosperma*) *muscaetoxicum*, *Lycopodium inundatum*, seems to be spreading by mass invasion to the white pine lands made sterile by the action of the forest fires, so that if no precaution is taken the whole of the Pocono tableland will be covered with a worthless scrub of *Comptonia asplenifolia*, *Pteris* (*Pteridium*) *aquilina*, *Quercus ilicifolia* (= *Q. nana*) representing the pine barren associations of species[2]).

1) That is an "Association of Species" or "species-guild" in a phytogeographic sense.

2) HARSHBERGER, J. W.: The comparative Age of the different floristic Elements of eastern North America. Proceedings Academy Natural Sciences of Philadelphia 1904: 601—615.

A consideration of the strand flora of New Jersey, which is well represented in the meadows of sedges, swamp rose mallow (*Hibiscus moscheutos*) and the forests of *Pinus rigida*, *Juniperus virginiana* &c. of the plate IV, reveals the fact that the time element is important in an explanation of the distribution of the sea-shore plants. If we contrast the character of the association of species on the northern and southern shore of New Jersey we find that the formations on Barnegat beach, for example, are usually open, while those on Wildwood beach are closed and have culminated in the forest type of vegetation. This argues for a greater age of the strand flora of Wildwood, as compared with that for example at Sea Side Park in the north, and this conclusion is substantiated by the fact that the bays behind the sandy sea islands are converted by the action of the tides and vegetation into salt marshes in the south, while in the north there are wide and open bays of brackish, or salt water [1]. The development of this coast flora must have been subsequent to the post-Pensauken uplift, but there is good reason to believe, that practically the same plants formed an association of species which fringed the continent wherever a sandy or gradual shoreline was exposed to the action of the sea. These plants migrated along the shore with every elevation and depression, now fringing some recently formed sea-sound, now encroaching upon some recently emerged sandbank. We find an interesting confirmation in the presence of typic seashore plants on the coasts of the great lakes. Such plants as *Ammophila arenaria* (= *A. arundinacea*, *Sabbatia angularis*, *Lathyrus maritimus*, *Gerardia purpurea*, *Euphorbia polygonifolia*, *Myrica carolinensis* are found not only on the shore of the Great Lakes, but some of them at the Lake of the Woods. The most satisfactory explanation seems to be that in post-glacial times the valleys of the St. Lawrence, Hudson, Lake Champlain and probably also lakes Ontario and Superior were then occupied by the sea, because of the northeast depression of the lands. During this period of submergence the typic seashore plants invaded the interior of the continent by way of the then existing seashore. Another interesting confirmation of the fact that the later periods of submergence and uplift had a powerful influence on the distribution of sea coast species is found in the present distribution of the swamp rose mallow, *Hibiscus moscheutos*, in the Atlantic coastal plain. This plant normally occurs in brackish marshes from Massachusetts to Florida and Louisiana and on lake shores in saline situations locally in the interior to western Ontario. When it occurs in fresh water swamps, it is reasonably certain that these swamps represent converted salt marshes or bays which were present during a former time of submergence. New Jersey shows this best. During the Pensauken submergence, southern central New Jersey was a sea island separated from northern New Jersey by Pensauken Sound. *Hibiscus moscheutos* in its present distribution in New Jersey follows the former shore line of that

1) HARSHBERGER, J. W.: An ecological Study of the New Jersey Strand Flora. Proceedings Academy of Natural Sciences of Philadelphia 1900: 623—671. Additional Observations on the Strand Flora of New Jersey. do. 1902: 642—669.

**Salt Marsh,** Southern New Jersey.

Distichlis and Salicornia. Hibiscus. — Juniperus virginiana on low dunes. Myrica carolinensis &c.

ancient island, for it occurs on both banks of the Delaware River to the head of tide water, in marshes along the New York Division of the Pennsylvania Railroad between Trenton and Newark, which follows the old sound bed and in the brackish marshes of the coast.

In the higher Appalachian Mountains of the southern states, we find a forest of firs, *Abies Fraseri*, accompanied by such trees and shrubs, as the yellow birch *Betula lutea*, mountain ash *Sorbus americana*, mountain maple *Acer spicatum*, red elder *Sambucus racemosa* and wild red cherry *Prunus pennsylvanica*. Other characteristic species like the striped maple *Acer pennsylvanicum*, hemlock *Tsuga canadensis*, white pine *Pinus strobus*, and the arbor vitae *Thuja occidentalis* to much lower elevations (900 meters or less). Along the crest of the highest mountains of this region usually at an altitude of 6000 feet (1800 meters) or upwards the green alder, *Alnus viridis* (= *A. alnobetula*), *Arenaria groenlandica*, *Potentilla* (*Sibbaldiopsis*) *tridentata* and *Trisetum subspicatum* are encountered. By far the greatest surface of the mountain region is covered with such woody species as *Betula lenta*, *Magnolia umbrella* (= *M. tripetala*), *M. acuminata*, *M. Fraseri*, *Acer saccharinum*, *Rhododendron maximum*, *Kalmia latifolia*, *Castanea americana* (= *C. dentata*). Mingled with these are *Juglans nigra*, *Liriodendron tulipifera*, *Carya alba*, (= *Hicoria ovata*) *C. tomentosa* (= *Hicoria alba*), *Quercus alba*, *Q. prinus*, *Ilex opaca*, *Hamamelis virginiana*, *Fagus americana* (= *F. ferruginea*), which are perhaps more characteristic of the Alleghanian flora than that lower down. The lower slopes of the Alleghanian flora than that lower down. The lower slopes of the mountains and the valleys between are largely occupied by extensions of the flora which distinguish the Piedmont plateau. Very characteristic species, especially along the streams are *Platanus occidentalis*, *Betula nigra*, *Tilia heterophylla*, *Celtis occidentalis*, *Liquidambar styraciflua*, *Morus rubra*, *Sassafras officinale* (= *S. sassafras*), *Diospyros virginiana*, *Nyssa sylvatica*, *Pinus virginiana* (= *P. inops*), *Pinus mitis* (= *P. echinata*), *Ulmus americana*, *Castanea pumila*, and *Quercus marylandica* (= *Q. nigra*).

*Origin of Mountain Elements.* There are many plants in the mountainous parts of the south which are probably the more or less modified descendants of that characteristic flora which in later Eocene or in Miocene time extended to high northern latitudes, also occupying the mountainous parts of what is now the north temperate zone[1]. To be reckoned here with more or less confidence, are[2].

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1 According to DE SAPORTA et MARION a vegetation of Magnolia, Lauraceae, Liquidambar, Anonaceae, Ilicaceae, Liriodendron etc., occurred on the mountains of southeastern France, at altitudes of 200 to 700 meters during the Pliocene. That a similar flora flourished contemporaneously in the mountains of eastern North America would seem by no means unlikely. Recherches sur les végétaux fossiles de Meximieux. Archiv. Mus. Nat. Hist. Nat. de Lyon 1: 304—324. 1875.

2) KEARNEY, THOMAS H. JR: The lower austral Element in the Flora of the southern Appalachian Region. Science new ser. XII: 836. Nov. 30, 1900.

Danthonia sericea Nutt.
Uniola gracilis Michx.
(= U. laxa L.).
Poa Chapmaniana Scribn.
Arundinaria macrosperma Michx.
» tecta Walt.
Lilium carolinianum Michx.
Ulmus alata Michx.
Parnassia grandifolia DC.
Decumaria barbara L.
Itea virginica L.
Crataegus uniflora Muench.
» rotundifolia Ehrh.

Berchemia volubilis Hill. (= B. scandens DC.).
Cissus ampelopsis Pers. (= Ampelopsis cordata Michx.).
Vitis (Muscadinia) rotundifolia Michx.
Aralia spinosa L.
Leucothoë (Andromeda) racemosa (L.)
Oxydendrum arboreum (L.) DC.
Gaylussacia dumosa Andr.
Vaccinium (Batodendron) arboreum Marsh.
Symplocos tinctoria L.
Chionanthus solitaria Rydb.

Most of the species, as well as many of the genera, comprised in this second category are characteristic neither of tropic nor of high northern regions. They belong in great part to groups which are most largely represented at present in the mountainous parts of the warm belt of the northern temperate zone, in both the eastern and western hemispheres.

To be considered in connection with this category of species are those which occur both within the main limits of the southern coastal area and in the mountains of the Appalachian region. With the exception of *Clethra* (which is largely tropic) all these genera have their present center of distribution in the warmer part of the north temperate zone. This may be said also of the larger groups to which many of them belong, e. g., the families Calycanthaceae, Sarraceniaceae, Hamamelidaceae, and Monotropaceae, and the tribes Hydrangeae of Saxifragaceae and Andromedeae of Ericaceae. Some of them are known to belong to floral types which were widely distributed in the northern hemisphere during the early part of the Tertiary, in not a few cases ranging, as far north, as Greenland and Alaska. Very broadly speaking several of these genera represent groups which appear to be on the wane, as distinguished from the dominant and aggressive types of neotropic origin which appeared later in the mountains and to which we shall refer. A faint indication of a coastal plain element in the mountain flora [1]) is perceptible, as far north, as West Virginia and southeastern Kentucky; while, on the mostly granitic outcrops in northern central Georgia and northern Alabama, of which Stone Mountain is a type, it is so extensive as to somewhat obscure the main flora. The occurrence of coastal plain species of southern origin (lower austral) at higher elevations in the midst of a transition flora demands attention.

Some of the species occurring on Lookout Mountain, but not reported from other stations in the mountains, e. g., *Pinus taeda*, *Cocculus* (*Cebatha*) *carolinus*, *Vaccinium* (*Batodendron*) *arboreum*, and *Spigelia marylandica* also

1 Kearney, Thomas H.: The lower austral Elements in the Flora of the southern Appalachian Region. Science new ser. XII: 832. Nov. 30, 1900.

extend farther up the Tennessee valley. This mountain especially near its southwestern end in Alabama, harbors a notable colony of lower Austral plants:

Pinus taeda L.
Xyris communis Kunth (= X. macrocephala Vahl).
Asimina parviflora Michx.
Cocculus carolinus L. (= Cebatha carolina Britton).
Sarracenia flava L. (var. oreophila).
Crotonopsis linearis Michx.
Berchemia scandens Hill (= B. volubilis DC.).
Vaccinium (Batodendron) arboreum Marsh.
Gelsemium sempervirens L.
Spigelia marylandica L.
Chondrophora virgata Nutt. (= Bigelovia nudata var. virgata Nutt.).

The species physiologically of the hot coast plain (austro-riparian) form not infrequently, in peculiarly favorable localities diminutive pine barrens which cover sandy river bottoms and the dry sunny lower slopes of the hills, in numbers so pronounced, that a botanist suddenly set down amongst them might be puzzled for a moment as to his whereabouts. Two colonies of this character may be referred to.

Along the French Broad River below Paint Rock, North Carolina, and just within the limits of Tennessee, the stream is bordered by limited strips of flat land, which are mostly covered by a small growth of yellow pine *Pinus mitis* (= *P. echinata*). The altitude of the river banks is here from 1150 to 1200 feet (345 to 360 m) above the sea. In these grooves, the herbaceous flora is like the coastal pine barren flora. The following list of species all of which are abundantly represented, indicates the character of this flora.

Erianthus alopecuroides L.
Andropogon argyraeus Schult.
Chrysopogon (Sorghum) nutans var. Linnaeanus (= Sorghastrum Linneanum Hack.).
Sporobolus asper Michx.
Danthonia sericea Nutt.
Gymnopogon ambiguus Michx. (= G. racemosus Beauv.).
Triodia cuprea Jacq. (= Tridens seslerioides Michx.).
Crataegus uniflora Muench. (= C. parvifolia Soland.).
Schrankia (Morongia) angustata Torr. & Gray.
Stylosanthes riparia Kearney.
Croton glandulosus L.
Vitis rotundifolia Michx.
Hypericum (Sarothra) Drummondii Grev. & Hook.
Bignonia crucigera L. (= B. capreolata L.).
Elephantopus tomentosus L.
Eupatorium aromaticum L.
Chrysopsis graminifolia Michx.
Silphium asteriscus L.
» compositum Michx.

Another noteworthy austro-riparian colony, according to KEARNEY [1]), occurs at a mean elevation of about 1000 feet (300 meters), in the canyon-like valley of the Hiwassee River, in extreme south-eastern Tennessee. Some of the most important species are:

1) KEARNEY, THOMAS H. JR.; l. c. 835.

Erianthus alopecuroides L.
» contortus Ell.
» brevibarbis Michx.
Andropogon argyraeus Schult.
» Elliottiii Chapm.
Paspalum purpurascens Ell. (= P. Boscianum Fluegge).
Panicum gibbum Ell. (= Sacciolepis gibba Ell.).
» viscidum Ell.
Danthonia sericea Nutt.
Uniola longifolia Scribn.
Poa Chapmaniana Scribn.
Decumaria barbara L.
Baptisia alba L.
Aralia spinosa L.
Ptilimnium capillaceum Michx. (= Discopleura capillacea).
Phlox amoena Sims.
Melothria pendula L.
Liatris (Lacinaria) graminifolia Walt.
Helianthus angustifolius L.

## 3. Southern Atlantic States and Mississippi Valley.

We now come to the difficult question of the probable past history of the lower austral plants which occur today in the Appalachian region. In studying this floral element, one soon reaches the conclusion that it comprises species which are markedly different not only in their systematic relationships, present distribution in the region and probable past history, but even, to a considerable degree, in their ecologic constitution.

*Neotropic Elements.* A most pronounced element consists of plants of probably neotropic origin, which made their first appearance, as we have seen, in the Appalachian region in geologically very modern times, probably after the close of the glacial epoch. The following list embraces species which probably from their distribution elsewhere, or from their affinities, are most likely to have had this history.

Erianthus alopecuroides L.
» brevibarbis Michx.
» contortus Ell.
Andropogon argyraeus Schult.
» Elliottii Chapm.
Panicum viscidum Ell. (= P. scoparium Lam.).
Muhlenbergia capillaris Lam.
Sporobolus asper Michx.
Gymnopogon ambiguus Michx. (= G. racemosus Beauv.).
Triodia cuprea Jacq. (= Tridens sesleroides Michx.).
Cyperus echinatus Ell. (= C. Baldwinii Torr.).
Kyllinga pumila Michx.
Xyris communis Kunth.
Commelina hirtella Vahl.
Yucca filamentosa L.
Agave virginica L.
Pogonia divaricata L.
Phoradendron flavescens Pursh.
Asimina parviflora Michx.
Cocculus (Cebatha) carolinus L.
Schrankia (Morongia) angustata Torr. & Gray.
Stylosanthes riparia Kearney.
Centrosema (Bradburya) virginiana L.
Chrysopogon nutans var. Linnaeanus (= Sorghastrum Linneanum Hack.).
Paspalum longipedunculatum LeConte.
» purpurascens Ell. (= Boscianum Fluegge).
Panicum gibbum Ell. (= Sacciolepis gibba Ell.).
Panicum angustifolium Ell.

Clitoria mariana L.
Crotonopsis linearis Michx.
Ascyrum stans Michx.
Hypericum densiflorum Pursh.
» (Sarothra) Drummondii Grev. & Hook.
» virgatum Lam.
Rhexia mariana L.
Jussiaea decurrens Walt.
Gelsemium sempervirens Ait.
Cynoctonum mitreola L. (= Mitreola petiolata T. & G.).
Spigelia marylandica L.
Callicarpa americana L.
Gratiola sphaerocarpa Ell.
» viscosa Schwein.
Bignonia crucigera L. (= B. capreolata L.).
Yeatesia laete-virens Buckl. (= Y. viridiflora Nees.).
Diodia virginiana L.
Melothria pendula L.
Eupatorium aromaticum L.
Chrysopsis graminifolia Michx.
Silphium asteriscus L.
Tetragonotheca helianthoides L.
Coreopsis major Walt. (= C. senifolia Michx.).
Coreopsis auriculata L.
Marshallia lanceolata Pursh var. platyphylla Curtis.
Liatris (Lacinaria) graminifolia Walt.
Pluchea petiolata Cass.
Silphium compositum Michx.
Helianthus angustifolius L.
Helenium nudiflorum Nutt.

By far the greater number of these neotropic species in the above list belong to groups, whether genera, tribes, or families, which are chiefly tropic in their distribution. Thus of the three most largely represented families, the Gramineae, the species belong chiefly to the tribes Andropogoneae and Paniceae; and the Compositae to Eupatorieae and Helianthoideae. This category is remarkable in consisting almost entirely of herbaceous species. Most of them are of distinctly xerophytic structure, loving a dry sandy soil and much light and heat.

The extremity of peninsular Florida is remarkable from a floristic standpoint in the presence of so many tropic species many of which have been received through the Bahama islands and perhaps some of them directly from the Greater Antilles. In all probability part of this migration occurred during the Eocene period for during the Eocene elevation there was probably a landway from Cuba across the Bahama banks to Florida, as evidenced by geology and by the fact that certain groups of Antillean land mollusks according to ORTMANN[1]) crossed that bridge. Perhaps this land connection continued until Miocene times, or at any rate peninsular Florida was then identified with the Bahama islands for geologists have proved that during this time the Gulf Stream did not form any barrier to plant distribution northward because it flowed out of the American Mediterranean, as now, but through a passage across the northern half of Florida.

Subsequent to the Miocene, the Bahama islands were again submerged for

1) ORTMANN, A. E.: The geographical Distribution of freshwater Decapods and its Bearing upon ancient Geography. American Philosophical Society XLI: 267—400. 1902.

the present Bahama group of islands is of very recent geologic history, the last uplift being placed not earlier than the late Tertiary by BRITTON[1]) and others. The flora clearly of the Bahamas and that of Florida is of southern derivation, a large number of the known indigenous species, as before shown, being common to the near by and older islands of Cuba and Haiti, while many of the species are closely related to plants from these islands. The chief agents in the introduction and distribution of the plant populations of the Bahamas and Florida being migratory birds, supplemented by winds and ocean currents. Notwithstanding the geologically short period that the Bahamas have been above the sea, they have witnessed the evolution by mutation or otherwise of numerous species, there being many endemic plants known and many more will be made known, as the result of the recent explorations. Many of these, it is believed, will prove to be examples of rapid evolution. The tropic flora of southern Florida then is represented by species that migrated into Florida since the last upheaval of the present Bahama chain of islands. The modern flora of southern tropic Florida essentially consists of the recent introductions which have undergone mutation into new forms. Emphasis should at this point be made of the fact that the agencies enumerated above were at all times, whether in the Eocene, or Pleistocene, instrumental in the migration and intermingling of plants, although the land bridges also afforded an easy means of access into an area connected by such a bridge with another land mass possessing a richer flora. Of the 492 plants common to the Bahamas and the United States, there are 40 previously enumerated that are only found in these two regions. Such plants as *Myrica cerifera*, *Vitis rotundifolia*, *Rhus Blodgetii*, *Eragrostis Elliotii* and *Baccharis angustifolia* have in all probability migrated from the mainland to the Bahamas. Dividing these islands into two groups, the first or northeastern, according to COKER, comprises Andros, New Providence, Abaco, Great Bahama, Berry islands and surrounding cays, and the second, or southwestern group, consisting of Eleuthera and all the islands south of it[2]). It will be seen from the above list that all, except eight of the plants confined to the United States and the Bahamas are found only on the northwestern group. Analyzing the figure 492, we find that 322 species are common to the Bahama islands and southern Florida and 170 species are common to the Bahamas and the southern United States. Selecting a representative number of plants the following species found in southern Florida also occur in the Bahamas. Those marked by an asterisk (*) occur in Cuba; those with two asterisks (**) in the Greater Antilles; those with a cross (†) in Mexico and Central America, while those with a paragraph (§) in South America.

1) BRITTON, N. L.: A botanical Cruise in the Bahamas. Science new ser. XXI: 628. April 21 1905.

2) COKER, WILLIAM C.: Vegetation of the Bahama Islands. 1905: 194—198. Extracted from publication The Bahama Islands of the geographical Society of Baltimore.

Juniperus (Sabina) barbadensis L. (**)
Cyclospathe Northropii Cook.
Pseudophoenix Sargentii Wendl.
Thrinax argentea Lodd. (= Coccothrinax jucunda Sarg.) (*†**)
» floridana Sarg. (*)
Tillandsia balbisiana Schult. (*)
» aloifolia Hook. (*†**)
» fasciculata Sw. (*†§)
» utriculata L. (*†§)
» recurvata L. (*†§)
*Agave sisalana Engelm.* (**†)
Swietenia mahagoni Jacq. (*†§**)
Croton linearis Jacq. (*)
Excoecaria lucida Sw.
Hippomane mancinella L. (*†§**)
Hypelate trifoliata Sw. (**)
Gouania domingensis L. (**†)
Canella Winteriana L. (**†)
Rhizophora mangle L. (*†**)
Bletia verecunda Sw. (***)
Epidendrum nocturnum L. (*†)
Polystachya luteola Hook. (***†)
Coccolobis (Coccoloba) uvifera L. (*†§**)
Cassytha filiformis L. (*†**)
Chrysobalanus icaco L. (*†§**)
Caesalpinia (Guilandina) crista L. (**†)
Byrsonima lucida Sw. (*)
Bursera simaruba L. (*†**)
*Eugenia longipes Berg.* (***)
» monticola Sw. (***)
Conocarpus erecta L. (*†**)
Avicennia nitida Jacq. (***†)
Genipa clusiifolia Jacq. (***)
Pectis linifolia L. (= P. Lessingii Fernald) (**)

The distribution of plants in the southern extremity of Florida is an interesting confirmation of the historic development of a flora. Seven plant formations can be recognized, viz., 1 the sea strand formation; 2 the mangrove swamp formation; 3 the everglade formation; 4 the prairie formation; 5 the savanna formation; 6 the pine-land formation; 7 the hammock-land formation. Historically, the sea-strand formation and the hammock-land formation are the oldest floristically speaking. The strand flora, consisting of such plants as *Uniola paniculata*, *Panicum amarum*, *Ipomoea Pes-caprae*, *I.* (*Batatas*) *littoralis*, *Iva imbricata*, *Cakile maritima*, *Agave decipiens* (on tropic section), has existed as an element of peninsular Florida since the land was elevated above the sea and perhaps was derived from an earlier seashore flora, which existed along the shore of the mainland, or the coasts of the larger and more elevated sea islands.

Nearly all the tropic species recently added to the flora of the United States were discovered in or about the hammocks, which are essentially duplicated by similar formations in the West Indies. The total area of the hammock-land is relatively insignificant, when compared with the pine-lands, yet the flora, as shown in the enumeration below is as rich, if not comparatively richer.

| | |
|---|---|
| Pinelands . . . . | 43 per cent. |
| Hammocks . . . . | 42 per cent. |
| Everglades . . . . | 15 per cent. |

The hammocks consist of isolated groups of hardwood trees, shrubs and vines. These hammock formations with an overlying soil, thicker than the pine-lands, due without doubt to the accumulation of vegetal detritus, vary in

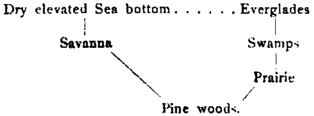
size from an acre to many hundred acres and are scattered as islands in the everglades and pine-forests instead of surrounded by the ocean, as they formerly were before the sea bottom between them became dry land by elevation. The trees, shrubs and woody vines harbor an almost incredible growth of plants of various categories. The growth of epiphytes is especially striking, for in numerous cases the tree trunks and branches are completely clothed with air plants, and so prolific are the orchids and bromeliads that many individuals are forced to growth on the ground and on the neighboring pine trees[1]). Here occur the great majority of flowering plants now known to be common both to the West Indies and the mainland of North America. It is in the hammock where one finds the mastic *Sideroxylon mastichodendron*, crabwood *Gymnanthes lucida*, satin-leaf *Chrysophyllum oliviforme* (= *C. monopyrenum*), gumbo-limbo *Bursera gummifera* (= *B. simaruba*), prince-wood *Exostema caribaeum*, white wood *Drypetes crocea* (= *D. lateriflora*), and manchineel *Hippomane mancinella*[2]). As the rock of New Providence Island of the Bahama group is essentially identic with that of Florida south of Miami, and as there are many trees and shrubs common to the two regions, as well, as to Cuba, while many species are endemic to each of the three regions, we are forced to conclude from the evidence that the flora gives, that geologically and to a certain extent floristically the hammock lands formed originally part of the Antillean region. The hammock lands represent perhaps part of the ancient system of keys which existed at the time when the Gulf Stream left the American Mediterranean through a channel which existed across the northern half of Florida. It was when these islands formed an extended archipelago coextensive with the Bahamas that the hammocks were occupied by their present flora which, therefore, shows the closest relationship to that of the near by Bahama islands. With the elevation of the land through the epeirogenic movements of the earth's crust, through the agency of coral polyps, vegetation, ocean and wind currents, the Gulf Stream was directed into its present channel and the sea islands which now exist in south Florida in the form of hammocks, were connected by dry land, or by partially submerged banks to form the present peninsula of Florida, and after sufficient elevation had taken place, the surrounding sea flat was transformed into a savanna or into the vast spring known as the everglades.

With the appearance of level plains by the removal of the shallow sea over a sandy bottom, isolated trees and herbaceous plants, which associated together formed the savanna formation, appeared and clothed the ground. Imperceptibly, these savannas were transformed into the pine-land formation. This formation is characterized by a scattering growth of *Pinus heterophylla*

1) Consult the articles by SMALL, J. K. and BRITTON, N. L. in Journal New York Botanical Garden III, No. 26, Feb. 1902; IV, No. 39, March 1903; V, No. 51, March 1904; V, No. 55, July 1904; V, No. 56, Aug. 1904 to which the writer is indebted for many facts herein set forth under the new cloak of generalization.

2) GIFFORD, JOHN: Southern Florida. Forestr and Irrigation X: 406. Sept. 1904.

(= *P. cubensis* = *P. caribaea*) and numerous shrubs, shrubby herbs and herbaceous perennials together with a few annuals. Four species of palms belonging to the genera *Sabal*, *Serenoa*, *Coccothrinax* and the Sago palm *Zamia floridana*, are prominent representatives of the pineland formation. These pine-lands are light and airy with comparatively thin soil. The growth of timber is scattered and the plants found in this formation are not duplicated in the West Indies. Relatively then the flora of the pineland formation is younger than that of the hammocks and may be older, or younger than the everglade formation, according to whether this association of species encroached on elevated plain land, or whether it captured grassland or the everglade formation. The evolution of the pine woods may be represented for sake of clearness diagramatically, as follows:




The culmination from either condition has been a pine forest. The everglades, then historically speaking, may be older than the pine woods, or they may be younger, if the pine woods have been developed from a savanna, or a prairie. Whatever their position in point of time, they cover an area about one hundred miles wide and perhaps one hundred and fifty miles long, the elevation being about 18 feet above sea-level. The everglades consist of an extended saw-grass swamp traversed by winding river-channels, and covered with scattered hammock-lands. Its flora consists of grasses, sedges and other herbaceous plants (*Apios tuberosa*, etc.) among which are many aquatic and mud inhabiting plants (*Peltandra virginica*, *Saururus cernuus*). The vegetation of the everglades is of a more northern character than that of the hammock lands, more than half the species of which are native to Cuba and the Bahama islands, so that often one can stand with one foot in an association of northern species and the other in an association of plants restricted to the tropics.

The Mangrove formation represents an important element in the flora of southern Florida. The mangrove swamps are particularly abundant along brackish shores and along the sea-islands, the so-called Florida Keys[1]). Their vegetation is confined almost exclusively to the mangrove trees and such few tillandsias and orchids as grow upon their branches. Frequently on the borders of these swamps occurs a large showy species of *Acrostichum* with leaves often six to eight feet long. The area shut off from the sea by the fringe of mangrove becomes dry ground and eventually grassland (in Florida a "prairie").

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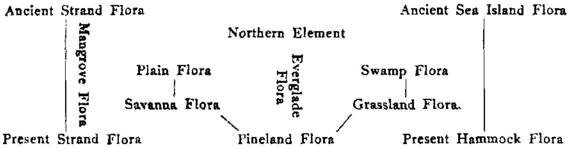
1) PHILLIPS, O. P.: How the mangrove Tree adds new Land to Florida. The Journal of Geography II: 1—14. Jan. 1903.

The results of this survey as to the southern extremity of Florida may be arranged below:




*Mississippi Valley Flora.* As has already been mentioned, the central valley of North America during the upper Cretaceous period was mostly under water. In lower Tertiary time, these waters had receded from the north leaving the southern part of the Mississippi valley still submerged. In the late Tertiary, the water had still further receded, only a narrow embayment representing the once more extensive northward projecting lobe of the ocean. (See Fig. 3, 4, page 179.) A plain was formed with the recession of the sea, and in all probability it stood then much at its present elevation. This plain was invaded at once by the grass formation which formed dense mats of turf with deeply penetrating roots. Thus we have the vegetal covering of North America at the close of the Tertiary period divided into two great kinds, forest and plain. The plain flora consisted of turf-builders which characterize the prairie and plains of the present day. During the middle Tertiary period down to the Pleistocene, the grassy plains were much less extensive than now, because the climate of the eastern foothills of the Rocky Mountains was much more humid, in part, because of the presence of Lake Bonneville in the Great Basin permitting the western forest trees to grow east of their present position, and in part, because the characteristic forest of the east occupied a much more extended area, especially during Miocene times. The recession of the inland waters was followed by a much drier steppe climate and the western trees receded to about their present position. The arid plains east of the Rockies thus had their origin, and their floral covering was derived from several sources of supply.

1. An invasion took place from the Great Basin and Mexico. This may be called the southwestern arid contingent.

2. The prairie contingent derived from the prairies lying immediately to the east.

3. A Rocky mountain element which invaded the region from the west and

4. A relict flora representing those plants which remained even after the climate had become more arid and forbidding to the majority of western forest trees. However, east of these dry plains existed a grass covered territory or prairie on both sides of the Mississippi River. The invasion of trees into this area was not possible because the turf and mat formation was so dense and because a steppe climate with strong winds prevented the encroachment of

forest trees, so that the prairie flora, if disturbed always culminated again in the grass formation. Prof. LESQUEREUX[1]) believed that the failure of forest vegetation to occupy the prairies was due to the chemic nature of the soil, coupled with its exceeding fineness. Most of the older geologists with LESQUEREUX believed that all our prairies not only the low prairies along our lakes and river bottoms, but also the high rolling prairies were produced by the slow recession of temporary sheets of water of various extent; that these lakes were transferred into swamps and by and by drained and dried. That much of this prairie soil is not stratified, as if laid down in water, that it contains no remains of leaves, insects, fresh water or marine shells seems to militate against the lacustrine origin of the present prairie soils, however, it might have been in early Tertiary times. Several other theories have been advanced to account for the origin of the prairies. Dr. WHITE[2]) says without the least hesitation that the real cause of the prairies is the prevalence of annual fires, originally maintained by the Indians. Professor J. D. WHITNEY concurs with LESQUEREUX that the cause of prairies at least east of the Mississippi is mainly the fineness and depth of the soil, while another writer believes the absence of trees is mainly dependent on the rainfall[3]): a view disproved by the rain charts.

We know that during the glacial period much debris, glacial silt, gravel and till was carried down by the Mississippi River and its tributaries. We can safely imagine the formation of large temporary lakes, on the bottom of which would be deposited the material derived from the melting ice front and streams which emerged from the ice beneath. Lake Agassiz, a glacial lake of this type, occupied an area of more than 100,000 square miles in northwestern Minnesota, northeastern Dakota and a considerable portion of Manitoba. On the bottom of this lake was deposited during the comparatively brief time of its existence, silt to a depth as yet undetermined, but known to be at east 100 feet[4]). Undoubtedly some of the superficial prairie soil had a lacustrine origin when temporary or shallow lakes were present in the great central valley, but the larger part of it according to the most recent studies had a different origin, for we find, that most of the glaciated portion of this region is deeply covered with fine loam called loess which in some places may have had its origin as a water deposit, but which in all probability was deposited by wind action. In the United States, the *Loess* which in the north lies over the glacial drift, covers thousands of square miles throughout the drainage basin of the Mississippi River. It is found in Ohio, Indiana, Michigan, Iowa, Kansas, Nebraska, Illinois, Tennessee, Alabama, Mississippi, Louisiana, Arkansas, Missouri, Kentucky and the Indian Territory. According to Aughey,

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1) HAY, O. P.: An Examination of Prof. LEO LESQUEREUX's Theory of the Origin and Formation of Prairies. American Naturalist XII (1878) 299.

2) WHITE: Geology of Iowa I: 133.

3) TODD, J. E.: Distribution of Timber and Origin of Prairie in Iowa. American Naturalist XII (1878) 91.

4) MERRILL, GEORGE P.: A Treatise on Rocks, Rock-weathering and Soils. 1897: 290.

it prevails over at least three-fourths of Nebraska to a depth ranging from 5 to 150 feet and furnishes a soil of extraordinary strength and fertility. The altitude of the loess deposits is by no means uniform. In the lower part of the Mississippi valley, it is found at an elevation of about two hundred and fifty feet. In the upper Mississippi valley, it rises to a height of seven hundred feet above the bed of the river [1]). No general depression of the region will account for these irregularities and we must have recourse to wind action. Loess forms a mantle at the surface over all the Kansas area and covers with a thin sheet most of the southern portion of the Iowan drift. As a rule, the deposit is a very fine-grained, yellow silt covering alike the summits, slopes and valleys. At numerous points, the loess attains a depth of fifteen to twenty five feet. In many of these deeper deposits, the shells of pulmonate land mollusks belonging to the genera *Zonites* (*Zonitoides*, *Euconolus*), *Patula* (*Oreohelix*, *Pyramidula*), *Helicodiscus*, *Ferussacia* (*Cochlicopa*), *Pupa* (*Bifidaria*), *Vertigo* (*Sphyrodium*), *Mesodon* (*Polygyra*), *Vallonia*, *Succinea* have been found, while a few species of *Limnaea*, found in fresh, water occur. In such beds, the loess is usually quite calcareous and segrations of lime form small nodules ("loess-kindchen").

Professor CALVIN has shown that the materials of the loess of central and southern Iowa were probably derived from the finer constituents of the Iowan drift [2]). It would seem that the conditions during the glacial period would be exceptionally favorable for strong northerly and westerly winds whose sweep over the ice sheet would be unobstructed. Then too the finer, loose materials, liberated by the melting of the ice, would be in prime condition to be gathered up and swept along by the winds. During all these physiographic changes which began with the oncoming of the glacial period and closed with the formation of loess, we must believe that the original grass flora of the plains maintained itself, but during the ice age typically in a more southern locality for in the north central prairie region, the vegetation and prairie vegetation was destroyed and replaced by an arctic flora along the ice front. Such boreal trees as *Betula papyrifera*, *Populus balsamifera*, *Populus tremuloides*, *Acer glabrum* were left behind according to CLEMENTS after the disappearance of the northern flora. As a closed vegetal formation the grass vegetation prevented trees from ever reaching the prairie areas. We have evidence of a continuous grassy covering of parts of this central plain from the time that it was elevated above the sea sometime during the Tertiary period for the life of the Miocene is in all respects a great advance upon that of the Eocene and Oligocene. The grasses greatly multiplied and took possession of the open plains producing ideal conditions for the growth of forage plants for the herbivorous animals.

That the grassy covering of the plains has been subjected to physiographic

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1) WRIGHT, G. FREDERICK: The Ice Age in North America 1889: 360.

2) SAVAGE, T. E.: Loess. Iowa Geological Survey XIII (1902) 242.

changes is illustrated by a study of the loess deposits. AUGHEY gives the following section[1]) of the loess of Nebraska:

| | | |
|---|---|---|
| 1. | **Loess** | **4 feet.** |
| 2. | **Blacksoil** | **2 »** |
| 3. | **Loess** | **4 »** |
| 4. | **Blacksoil** | **1-1/2 »** |
| 5. | **Loess** | **5 »** |
| 6. | **Blacksoil** | **1-1/2 »** |
| 7. | **Stratified loess** | **15 »** |

It would seem that the loess was deposited that it was covered by a grassy sod, which lasted for sometime to be covered again by loess and that the black soil layers represent the soil formed by the accumulation of material due to the grass vegetation. For deposits of fine grained loess-like beds are forming at the present time, wherever dust-laden winds have their velocity checked and especially where a carpet of grass or other vegetation covers the surface in such places so as to retain the dust that falls upon it.

*Origin of Treeless Plains.* (*Prairie Flora.*) The origin of the treeless prairies is found in the past physiographic conditions of the region coincident with the loess formation and the gradually increasing dry summer climate and hot scorching winds, for where the dryness of the summers make the growth of trees precarious, the nature of the soil, whether coarse or fine, becomes the controlling factor, starting with a grass flora when the central plain was formed. This plant formation was maintained and preserved because through the character of the soil, lacustrine at first and subsequently glacial and loess, the grasses were enabled to form close mats sufficiently dense to prevent the encroachment of tree vegetation. The grass formation represents a type of vegetation which is peculiarly adapted edaphically to maintain itself in the fine loess soils of the prairie in a region with strong and cutting winds and dry climate and to successfully hold its own against other plant formations. The experience of orchardists and tree planters in the prairies has demonstrated that the eastern trees, on good soil, cannot compete singly with the prairie grasses, no matter how great a supply of moisture is furnished either by rainfall, or irrigation. There is only one way in which trees of the East can overcome the prairie grasses and that is by advancing in solid phalanx. This method is necessarily very slow and accounts for the lack of time since the glacial epoch for the trees to extend their supremacy over the whole prairie region. The buffaloes also had their influence in preserving the prairie mat and the Indians hunting the buffaloes set fire to the dry grasses and still further increased the prairie tendencies[2]). That this historic explanation is the correct one is demonstrated by the fact that where the loess is shallow and where the glacial gravels protrude there are usually found groves of forest trees. The groves of trees which stand isolated upon the prairie grow upon

1) AUGHEY: Physical Geography and Geography of Nebraska: 276.

2) See CLOTHIER, G. L.: Forestry and Irrigation IX: 95. Feb. 1903.

coarse soil, for in some cases the deposits of coarse drift have escaped being covered by the prairie soil, because a little more elevated in these spots, or the increased height has favored the washing away of the finer particles by the rain. Then again where the continuity of the fine prairie soils is interrupted by a gulch or water course, by stream action, the closeness of the prairie sod is interrupted and trees appear. For this reason, if the heights of the bluffs be considerable and the eroding power of the stream sufficient to cut the country up into a succession of ravines with but little level ground between them then the whole region will be more or less covered with timber, as is the case with northeastern Iowa, although the conditions with regard to moisture are less favorable than in other parts of the state [1]).

Another interesting confirmation of this view is found on the Edwards Plateau of Texas which is the rough deeply eroded southern margin of the Great Plains. If the plateau were an uneroded highland, climatic conditions remaining unchanged, the vegetal covering would be an open grass prairie. As a matter of fact it is being cut down to the coast level, as fast, as erosion can do it, and coincident with this, it is in process of transformation from a grass prairie to timberland. Erosion has resulted in breaking up the heavy sod covering which of itself operated effectually to keep out tree growth.

Similarly the invasion of trees in coast plain of Texas illustrates their dependence on edaphic conditions. The soils here consist of compact clays and silts interspersed with areas having a larger proportion of sand, and, therefore, more porous soils. These latter were more easily captured by forest, the compact soil more slowly. Thus one finds alternating areas of forest and prairie [2]).

The grass formation or prairie formation is clearly older floristically speaking than the forest groves and forest areas along the streams. As will be shown subsequently, the grass formations are endemic, while the forest trees have been derived in the main from the great southeastern forest previously described, while part of them have entered the North American prairie district from the west. The reason why the invading trees extend westward and northwestward into the prairie country from the Mississippi valley proper along which they have migrated, thus has a reasonable physiographic and climatic explanation.

The distribution of the timbered and prairie tracts in Wisconsin illustrates the dependence of the forest growth on the geologic and historic conditions rather than those having to do with climate. In the northern part of the state, is a region of dense forest, although as the statistics of rainfall show this is not a region of large precipitation. It is, however, covered with coarse detrital matter, plentifully distributed from the headquarters of the drift on Lake

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1) Whitney, J. D.: Plain, Prairie, Forest. American Naturalist X: 577, 656.

2) Bray, W. L.: Forest Resources of Texas. Bureau of Forestry U. S. Department of Agriculture Bulletin No. 47. 1904: 8 and 28.

Superior. Another area covered by silicious sandstone is the pine district of the state, while south of Wisconsin is the region of oak openings and prairies. And when we reach these treeless tracts, we find we have gotten entirely beyond the drift covered areas and that we are upon a soil made up of the insoluble residuum left from the disintegration of several hundreds of feet of limestone and dolomites.

The vegetation-center of the prairies is found in Nebraska, Iowa, Kansas and the Dakotas. From this center the typic plains flora slowly shades out toward both north and south. All vegetation regions, and none more readily than a plains region, where dissemination is so easily affected, borrow floral elements from adjacent regions, and it is only when this invasion has resulted to a pronounced degree that the original floral covering changes aspect. It is to the elucidation of these various elements in the plains flora that we must now direct our attention.

One of the most striking elements is the intrusion into the prairie region of trees and shrubs which have migrated from the northeast along the water courses emptying into the Missouri and Mississippi rivers. The trees which have entered Nebraska in this way according to BESSEY[1]) are *Juniperus virginiana, Asimina triloba, Salix* (3 species, 6 in number), *Populus monilifera* (= *P. deltoides*), *Tilia americana, Ulmus americana, U. racemosa, U. fulva, Celtis occidentalis, Morus rubra, Fraxinus americana, F. pubescens, F. viridis, Pyrus* (*Malus*) *coronaria ioensis, Crataegus* (4 species), *Amelanchier canadensis, Prunus virginiana, Prunus serotina, Gymnocladus canadensis, Gleditschia triacanthos, Cercis canadensis, Platanus occidentalis, Rhamnus lanceolata, R. caroliniana, Aesculus glabra, Negundo aceroides* (*Acer negundo*), *Rhus copallina, Juglans cinerea, J. nigra, Hicoria* (*Carya*, 5 species), *Quercus* (9—10 species), *Ostrya virginiana, Carpinus caroliniana*, and possibly one birch. Here are fifty-six or fifty-seven species of trees, which have without question come into the region from the forests of the southeast.

The trees which have entered the prairie region from the Rocky Mountain forests have made much less impression. Those which belong to this list are *Pinus ponderosa* var. *scopulorum, Juniperus scopulorum, Populus* (4 species), *Shepherdia argentea, Acer glabrum* and *Betula* (2 species).

Occasionally these eastern and western floral elements meet. BESSEY mentions a case[2]). Long Pine Creek runs northward about twenty miles to the Niobrara River through a deep and winding canyon. In this canyon, a blending of the eastern and western floras takes place. *Pinus ponderosa* var. *scopulorum* occurs in the greatest abundance here, but not eastward of this stream, while the black walnut *Juglans nigra* of the east is found associated with the bull pine, as also *Ostrya virginiana*, which with *Prunus*

1) BESSEY, C. E.: The Forests and forest Trees of Nebraska. Annual Report Nebraska State Board Agriculture 1899: 81—82; Plant Migration Studies, University of Nebraska Studies V, No. 1. Jan. 1905.

2) BESSEY, C. E.: A Meeting-place for two Floras. Bulletin Torrey Botanical Club XIV: 189.

*demissa*, *Ribes aureum*, *Rhus aromatica* var. *trilobata* (= *R. trilobata*), form an interesting ecologic association. The plants found near the buffalo wallows formerly constituted a noteworthy element distinct from the true prairie flora. The American buffalo delighted in rolling in and plowing up with its hoofs the soft muddy soil of the prairies, forming countless shallow depressions circular in shape very often retaining water for days. The plants found near such wallows were distributed by means of the mane of hair which clothes the front of the buffalo's head. Such plants as *Asclepias syriaca*, *Chenopodium album*, *Martynia proboscidea* (= *M. louisiana*), *Lippia cuneifolia*, *Panicum* (*Echinochloa*) *crus-galli*, *Rhus glabra*, and species of the following genera: *Trifolium*, *Thlaspi*, *Amarantus*, *Sinapis*, *Portulaca*, *Cenchrus*, *Stipa*, *Setaria*, *Elymus*, *Dactylis*, *Deschampsia*, *Euphorbia*, *Glycyrrhiza*, were thus carried, for the capsules of *Martynia proboscidea* (= *M. louisiana*), and the fruit of *Bidens*, *Glycyrrhiza*, *Styrax*, *Setaria*, *Elymus*, *Helianthus*, *Rhus trilobata*, *Obione* (*Atriplex*) *canescens*, *Amaranthus*, *Chenopodium* and the hispid twigs of *Euphorbia* have been taken from the matted hairs around the head of the male bison [1]).

The vegetation of the sand-hill region is made up of four elements at least: a proper element, a Mississippi basin element, consisting almost entirely of grasses and sedges intermingled with deep-rooted perennial herbaceous woody plants, a prairie element, and a foot hill element. To these one may add a Rocky mountain element, represented by the pine bluff formation along the Niobrara, and a northern element represented by *Betula papyrifera*, which also takes part in the Mississippi basin vegetation-element of the region [2]). The trees representing the Mississippi basin element are almost entirely confined to narrow belts which border the streams in the canyons. They are *Ulmus americana*, *U. fulva*, *Negundo aceroides* (= *Acer negundo*), *Fraxinus viridis*, *Fraxinus pubescens*, *Celtis occidentalis*.

The species occurring in the sandy hills which are proper to or most frequent in the foot hills are the following:

Aster canescens Pursh.
» longifolius Lam.
Oenothera (Anogra) albicaulis Pursh.
Artemisia frigida Willd.
» canadensis Michx.
Amelanchier alnifolia Nutt.
Astragalus missouriensis Nutt.
» mollissimus Torr.
Berula erecta Coville (= B. angustifolia Mert. & Koch).
Bromus Kalmii A. Gray.
» Porteri Nash.
Cactus (Mammillaria) viviparus Nutt.
Clematis ligusticifolia Nutt.
Cymopterus montanus Torr. & Gray.
Campanula rotundifolia L.
Crepis runcinata James.
Carduus ochrocentrus A. Gray.
Chrysopsis villosa Nutt. var. hispida A. Gray.
Chrysopsis villosa Nutt. v. canescens.
» » var. sessilifolia.
Cheilanthes gracilis Mett. (= C. Feei Moore).
Cleomella angustifolia Torr.

1) Berthoud, A. C.: Botanical Gazette XVII: 321—326. 1892.
2) Pound, Roscoe and Clements, Frederic E.: The Phytogeography of Nebraska 1900: 55.

Erysimum asperum DC.
» » DC. var. Arkansanum (= E. arkansanum Nutt.).
Galium boreale L.
Gnaphalium palustre Nutt.
Geum strictum Ait.
Gyrostachys (Spiranthes) stricta Rydb.
Hordeum pusillum Nutt.
Juncus bufonius L.
Lacinaria (Liatris) spicata L.
Leucocrinum montanum Nutt.
Lychnis Drummondii Wats.
Mentzelia nuda Torr. & Gray.
» decapetala Pursh.
Monarda citriodora Cerv.
Opuntia fragilis Nutt.
Orobanche ludoviciana Nutt.
Dalea (Parosela) aurea Nutt.
Physalis lanceolata Michx.
Phlox Hoodii Richards.
Pentstemon gracilis Nutt.
Pinus ponderosa Lawson var. scopulorum Engelm.
Plantago eriopoda Torr.
Sophora sericea Nutt.
Sporobolus airoides Torr.
Stipa comata Trin. & Rupr.
Thelesperma trifidum Poir.
Thermopsis rhombifolia Nutt.
Townsendia grandiflora Nutt.
Woodsia oregana D. C. Eaton.

If a comparison is instituted between the sand-hill formations and those of the prairie formations proper, it becomes evident, that the prairie element consisting of such species, as *Andropogon scoparius*, *A. provincialis*, *Koeleria cristata*, *Eatonia obtusata* and *Panicum Scribnerianum* occur in bunch grass formation of the sand hills, so that the bunch grass formation comprises plants of the prairie formation proper. These plants constitute the prairie element of the sand-hill flora. On the other hand, such plants as *Redfieldia flexuosa*, *Muhlenbergia pungens*, *Eragrostis trichodes*, *Cristatella Jamesii* and *Polanisia trachysperma* are peculiar to the sand-hills and may be looked upon as the proper elements. It is further evident that the plants of the blowout and sand draw formations constitute the sand-hill flora par excellence, while those of the bunch grass formation show decided affinities to the prairie flora proper.

The species of *Artemisia*, *Sarcobatus vermiculatus*, and the like, in the prairie province are Great basin elements. On the other hand, the undershrub formation of table-lands and bad lands are not proper foot-hill formations, nor are they proper to the prairie province. Where any of the species of these formations invade other regions of the prairie province, we may call them foot-hill elements. But in the province as a whole, these species are Great Basin floral element, and the formations are Great Basin elements in the vegetation of the foot-hill region.

The flora of the central North American plains has thus been analyzed. The old vegetable covering of the plains consisting of plants developed there under the peculiar conditions of environment has been invaded by a number of distinct elements from adjacent regions, so that the prairie flora proper, the sand-hill flora and the foot-hill flora, is a composite one consisting of endemic elements associated with the derived, all of which elements have been discussed and set forth in a differential manner above.

## 4. The Western Mountainous Elements and the Great Basin.

*Black Hills Flora.* The Black Hills are on the boundary line between South Dakota and Wyoming, the larger part lying within the former state. They constitute an isolated range about 120 miles long north-northwest, and 40 to 50 miles wide east and west. The nearest mountains are the Big Horn Mountains on the west and the Laramie Mountains to the southwest. The highest point is Harney's Peak 7368 feet (2245 m). The varied flora of these hills has been derived from several sources of supply. There are plants from the East, from the Saskatchewan region, from the prairies and table-lands west of the Missouri River from the Rocky Mountains and west thereof. The following trees and shrubs have come from the east and northeast.

Negundo aceroides Moench (= Acer Negundo L.).
Amelanchier alnifolia Nutt.
Betula glandulosa Michx.
» papyrifera Marsh.
Chimaphila umbellata Michx.
Cornus canadensis L.
» stolonifera Michx.
Corylus rostrata Ait.
Crataegus coccinea Linn.
Fraxinus lanceolata Borkh.
Juniperus virginiana L.
Linnaea borealis L.
Ostrya virginiana Mill.
Picea canadensis Mill.
Populus deltoides Marsh.
» tremuloides Michx.
Prunus americana Marsh.
» pennsylvanica L.
» virginiana L.
Quercus macrocarpa Michx.
Rhus glabra L.
Shepherdia canadensis Nutt.
Symphoricarpus racemosus var. pauciflorus Robb.
Ulmus americana L.

The Rocky Mountains in the west have supplied the following plants. Those marked with an asterisk * are found on the Pacific coast and in the northern Rockies; those with a dagger † in the Rocky Mountains southward.

*Berberis aquifolium Pursh.
†Betula occidentalis Hook.
†Ceanothus ovatus Desf.
† » velutinus Dougl.
†Cercocarpus parvifolius Nutt.
*Juniperus nana Willd.
†Pinus ponderosa Lawson var. scopulorum Engelm.
†Populus angustifolia James.
*Prunus demissa Nutt.
*Rhus trilobata Nutt.
†Rubus nutkanus Mociño.
*Spiraea lucida Dougl.
*Vaccinium Myrtillus L., var. macrophyllum Hook.

In the foot hills and the lower part of the Black Hills, the flora is essentially the same as that of the surrounding plains, with an addition of eastern plants that have ascended the streams. In the higher parts, the flora is of a northern origin. Most of the plants composing it are of a more or less transcontinental distribution, but often characteristic of a higher latitude. The only true trees of western origin, as shown in the lists above, are *Pinus ponderosa* and *Betula occidentalis*. The other full-sized trees are eastern.

The flora resembles therefore, as the tables show above, more that of the region of the Great Lakes than that of the Rockies [1].

*Recent History of the Rocky Mountain Flora.* The Stony Mountains a well-marked group by the head waters of the Missouri on the east, and the head waters of the Snake and Columbia rivers on the west, and the Park Mountains in southern Wyoming, central Colorado, and northern New Mexico, together constitute the Rocky Mountain system. The Stony Mountains are of diverse structure. There are a number of great ranges not systematically grouped, complicated by volcanic mountains, plateaus and hills. The ranges are moderately high; and by reason of the northern altitude and a fair amount of rainfall, they are covered for many months with snow, and here many beautiful streams have their origin. The flanks of the mountains and high plateaus are often covered with great forests, and the low foot hills with gnarled trees.

The ranges of the Park Mountains are more irregular than those of the Stony Mountains, and have a general north- and-south trend. Between the ranges are great valleys known as parks. The four most important are the North, Middle, South and San Luis parks. Above the timber line, the peaks are naked; below on the flanks of the mountains great forests stand, and often spread over elevated plateaus while the valleys are beautiful prairies, or parks. The central portions of the ranges are in the main composed of metamorphic rocks of great age. On the flanks of the mountains and out in the parks there are many beds of volcanic rocks which serve still further to modify the aspect of the ranges. In a few cases, especially on the western side, these volcanic beds have been piled up in mountain forms [2].

The history of region, as it has influenced the distribution of plants, is briefly, as follows: At the close of the Jurassic the first great upheavals took place [3]. Two lofty ranges of mountains — the Sierra Nevada and the Wahsatch were pushed up from the great subsiding area. These movements were followed by a prolonged subsidence during which Cretaceous sediments accumulated over the Rocky Mountain region to a depth of 9000 feet or more. Then came another vast uplift whereby the Cretaceous sediments were elevated into the crests of mountains, and a parallel coast-range was formed fronting the Pacific. The Rocky Mountains, with the elevated table-land from which they rise were permanently raised above the sea. The slopes of the land were clothed with an abundant vegetation, in which we may trace the ancestors of many of the living trees of North America. Vast lakes existed among the mountains, and the climate as proved by the presence of the lakes must have been much more humid than at present in the same region, and more

1) RYDBERG, P. A.: Flora of the Black Hills of South Dakota. Contributions from the U. S. National Herbarium III: 463—478. June 1896.

2) POWELL, J. W.: Physiographic Regions of the United States. National Geographic Monographs I, No. 3: 87—88. May 1895.

3) GEIKIE, SIR ARCHIBALD: Text Book of Geology. Third ed. 1893: 1078.

favorable to vegetation. The change in elevation during the Eocene was sufficient to drain the Eocene lakes, but the elevation attained was so small that vast Miocene lakes covered a large part of what now constitutes the eastern slopes of the mountains and continued into the Pliocene [1]). The climate was still favorable to a rich forest vegetation of deciduous and coniferous trees, which were with a slight preponderance of present western types the same, as covered the eastern part of the continent in the Appalachian Mountains and elsewhere. The changes which followed from the Pliocene down to the present produced vast changes in the topography of the country and in the vegetation. Great floods of trachyte, basalt and other lavas from many points and fissures over a vast space of the Rocky Mountains and westward were poured out. During the Pleistocene, the territory occupied by the Great Basin in great part a desert was then a lake region. One of these seas, named Bonneville occupied Salt Lake Valley, Utah and a contemporary lake called Lake Lahontan, situated in northwestern Nevada and extending into California existed, 886 feet deep. The climate was more humid than at present, but from the evidence that the basin itself affords, it seems safe to assume, that the average rainfall over Nevada at the time it was transformed into a lake region was probably not in excess of ten or fifteen inches a year. The times of marked expansion of these ancient lakes indicate an increase in mean annual precipitation, and times of contracted water surface, a decrease of rainfall. During this period, a rather uniform forest covered the western mountainous part of the continent, as far, as the Pacific. It will be remembered from what has preceded that the great ice sheet effectually separated the practically uniform Miocene vegetation of North America into two great groups, an eastern and a western, a change which had already begun when the Mississippi Valley was submerged and after its elevation was tenanted by a grass formation (see ante) accompanied by a steppe climate which still more effectually isolated the two great floras. The vegetation of the Rocky Mountains had many elements during the period of greatest lake extension which do not exist now for we have evidence from remains found in South Park that such genera as *Sequoia*, *Glyptostrobus*, *Myrica*, *Rhus*, *Sapindus*, *Ficus*, *Planera*, *Caesalpinia*, *Acacia*, *Zizyphus*, *Ilex* etc. existed there. With the disappearance of Lakes Bonneville and Lahontan, the gradual recession of the glaciers from the mountains which supplied these lakes with water and the disappearance of the great ice sheet from the northern part of the continent, an arid climate was introduced into the region. A great destruction of plant forms took place, especially the deciduous forest trees, while those species remained and were still further differentiated which adapted themselves, as some of the conifers did, to the more dessicating air and winds of a desert climate. The paucity of the ligneous flora of the region under consideration thus has a reasonable explanation. The whole region is marked by the scantiness, or absence of

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1) DANA, J. D.: Manual of Geology. Fourth ed. 1895: 933.

arboreal vegetation and of rainfall, the former being in great measure dependent on the latter. Its plains are treeless except along the water-courses; the mountains bear trees along sheltered ravines and on the middle and higher slopes upon which there is a considerable condensation of moisture; but, whenever they rise to a certain height (about 11,000 feet) in latitude 37° to 41°, they are woodless from cold and other conditions attending elevation, although the higher mountains enjoy an abundant condensation of moisture mostly in the form of snow. Three belts may, therefore, be distinguished in the vegetation of the Rocky mountains. 1. An arid and woodless district, which occupies a large part of the area. 2. A forest belt adorning the mountain slopes. 3. An alpine unwooded belt above the timber-line.

**1.** The *woodless region* may be divided into three well-marked districts: 1. the lower Rocky Mountain slopes (parks and higher foothills); 2. the desert interior, which will be considered separately under the caption, Great Basin and 3. the eastern lower foothills and mesas that merge into the eastern woodless plains[1]). The mesas are long, gently sloping, flat topped ridges extending from the bases of the foothills out towards the plains in an easterly direction. The vegetation of the north slopes of the mesas differs from that of the south slopes. The varying amount of moisture and sunshine are the important factors determining this difference. The east and west ends of the mesas are also different in their plants. The west end, being closer to the foothills, is sheltered from the afternoon sun, while the east is not thus protected. In the Spring small streams from the melting snow on the hills supply the west end of the mesas. Pine trees and *Populus tremuloides* grow there, while at the east, there are no trees at all. A gradual transition is noticed from the xerophytic formations of cactuses, *Yucca*, *Astragalus*, *Artemisia* and desert grasses on the east to the pine groves with their desert species of *Pulsatilla* and *Delphinium* on the west. Such shrubs as *Cercocarpus*, *Ribes*, and *Rhus trilobata* grow among the pines or east of them for a distance. Sometimes a mesa will have certain shrubs growing near the top on the south slope, but none farther down on the same slope. This is accounted for by the same fact that the spring snow lasts for a long time on the mesa, and as it slowly melts, it trickles down the south slopes to be quickly absorbed by the soil not far from the crest, while on the other hand, there is sufficient moisture on the north slope to permit the growth of shrubs for some distance from the foothills. Finally, it is important to note that the flora of the mesas is, a complex of mountain and plain species. At one season of the year, the vegetation of the mesas has the character of the mountain region. At another season, the prairie plants are more abundant. The slight change in the angle of the sun's rays causes the replacement of the *Leucocrinum* by a *Pentstemon* of higher altitudes. Later the prairie *Yucca* comes into blossom, and then

1) RAMALEY, FRANCIS: Remarks on the Distribution of Plants in Colorado east of the Divide. Postelsia 1901: 32.

there appear masses of *Arnica*, the near relatives of which belong to higher altitudes followed by prairie species of *Erysimum*, *Lithospermum*, *Petalostemon* and in the autumn by *Senecio* and *Gutierrezia*. These species of the two latter genera derived from different regions are the dominant ones of the herbaceous autumn flora. The *Senecio* occurs regularly in the mountains, while *Gutierrezia* is properly a plant of the plains. The flora of the lower foothills has been previously described. For the most part, the lower foothills are sparingly covered with pines. The north slopes of hills are better provided with trees than the south slopes. The herbaceous plants are chiefly those previously mentioned as occurring on the mesas, or in the parks. The mountain parks are somewhat level stretches of land encircled by high mountains, or hills. The altitude of these parks in the region under consideration is usually from 2500 to 3000 m. Plants to enter these parks from below must migrate by way of narrow canyons, or else over the passes from 600 to 1500 feet higher. We, therefore, find a paucity of plants from lower altitudes and relative abundance of proper mountain forms. Such plants, as *Aquilegia coerulea*, *Potentilla* (*Dasiphora*) *fruticosa*, *Pentstemon secundiflorus*, *Epilobium* (= *Chamanaerion*), *Eriogonum* spp., *Campanula* spp., with species of *Aster* and *Erigeron*. In these parks and on the surrounding foothills, the coniferous trees are the dominant plants, although here are found trees of *Populus tremuloides*. The coniferous trees are usually not in dense forests, but the parks are open with the development of a rich grass flora.

**2.** The *forests* adorning the mountain slopes require more extended description, because we can use the present distribution of the trees and shrubs in ascertaining the origin of the Rocky Mountain flora. Northward especially in northern British America, the Atlantic and Pacific forests join and intermingle. Southward with the Rocky Mountains trees are borne only on the mountains and high plateaus and along the banks of streams descending from the mountains. The mere botanic enumeration of the following species of trees gives no proper idea of the arboreal flora of the region.

Juniperus occidentalis Hook.
» californica Carr.
» virginiana L.
» scopulorum Sarg.
» pachyphloea Torr.
Cupressus guadalupensis Wats.
Abies concolor Lindl. & Gord.
» subalpina Engelm. (= A. lasiocarpa Hook.).
Pseudotsuga Douglasii Carr. (= P. taxifolia Britt.).
Picea Engelmanni Engelm.
» pungens Engelm.
Larix occidentalis Nutt.
Larix Lyallii Parlatore.
Pinus edulis Engelm.
» flexilis James.
» monticola Dougl.
» aristata Engelm. (= P. Balfouriana Wats.).
» chihuahuana Engelm.
» albicaulis Engelm.
» Murrayana Engelm.
» ponderosa Lawson var. scopulorum Engelm.
» arizonica Engelm.
Taxus brevifolia Nutt.
Populus angustifolia James.

Populus balsamifera L.
» Fremonti Watson.
» monilifera Ait. (= P. deltoides Marsh.).
» tremuloides Michx.
» trichocarpa Torr. & Gray.
Betula occidentalis Hook.
» papyrifera Marsh.
Ulmus americana Linn.
Morus microphylla Buckley (= M. rubra L.).
Juglans californica Wats.
» rupestris Engelm.
Quercus Emoryi Torr.
» hypoleuca Engelm.
» undulata Torr.
» grisea Liebm.
Condalia obovata Hook.
Olneya tesota Gray.
Parkinsonia Torreyana Wats.
Prosopis pubescens Benth.
Prosopis juliflora DC.
Acacia Greggii Gray.
Platanus Wrightii Wats.
Yucca brevifolia Engelm.
Fraxinus anomala Torr.
» pistaciaefolia Torr.
» viridis Michx. f.
Chilopsis saligna Don.
Arbutus Menziesii Pursh. var.
Sambucus glauca Nutt. (= S. caerulea Raf.).
Cereus giganteus Engelm.
Negundo aceroides Moench.
Acer grandidentata Nutt.
Sapindus marginatus Willd.
Prunus emarginata Walp.
» pennsylvanica L.
» angustifolia Nutt.
Pyrus sambucifolia Cham. & Schl.
Crataegus rivularis Nutt.
Amelanchier alnifolia Nutt.

It includes practically all of the trees inhabitating a region extending from the eastern base of the Rocky Mountains to the eastern base of the Sierra Nevada and Cascade ranges and north of the Mexican boundary, well into British America. The character of the flora at the two extremes are most widely different. There is a denser forest in the north, but it consists of fewer species. In the southern part on the other hand, and undue appearance of richness is given to a scanty sylva 1. by the exclusion of shrubs and 2. by including species which belong to the southern part of Arizona and New Mexico. Of the latter sort are *Yucca brevifolia*, *Cereus giganteus*, *Pinus chihuahuana*, *Pinus arizonica*, *Sapindus marginatus*, *Arbutus Menziesii*, *Fraxinus anomala*, *Fraxinus pistaciifolia*, *Platanus Wrightii*, *Quercus Emoryi* and *Quercus hypoleuca*. From the whole region oaks are conspicuously absent, as trees, though the forms just referred to as Mexican types form small trees in the southern portions of Arizona.

It is important to analyze the various floral elements of the Rocky Mountain flora in order to determine their origin. As has been mentioned after the retreat of the continental glacier which covered the Rocky Mountain region, as far, as central Montana and Idaho, the region south of this line became drier and drier owing to the causes above enumerated. An extensive territory both in the northern and southern Rocky Mountains was thus opened for the migration of trees, shrubs and herbs. Upon the direction of the migration and the character of the plant migrants depends the character of the floras in the northern and southern Rocky Mountain regions respectively.

The northern Rocky Mountains north of the Big Horn River valley including the mountains of Idaho and Montana, northwestern Wyoming and eastern British Columbia, Alberta and northward were tenanted from several main directions, viz., the north east and the east; the west and southwest. Far in the northern part of the interior of British Columbia and Alberta is found just such an assemblage of plants, as occur in many parts of eastern Canada, though mingled with unfamiliar plants. This flora appears to run completely across the continent north of the great plains and it characterizes a region of moderately heavy rainfall, summers not excessively warm and cold winters. Thirteen species of trees and shrubs entered the northern Rocky Mountains from the northwest Pacific coast:

Abies grandis Lindl.
Larix occidentalis Nutt.
Sorbus sambucifolia Cham. & Schlecht.
Rosa gymnocarpa Nutt.
Chrysothamnus viscidiflorus Nutt.
Prunus emarginata Walp.
Echinopanax (Fatsia) horridum Smith.
Prunus demissa Walp.
Menziesia ferruginea Smith.
Lonicera utahensis Watson.
Phyllodoce glandulifera Hook.
Ledum glandulosum Nutt.
Spiraea pyramidata Greene.

Five species of a similar origin pursued a somewhat similar direction, but migrated eastward to the Black Hills and Lake Superior, viz.,

Salix fluviatilis Nutt. (= P. longifolia Muhl.).
California to British Columbia, east to Missouri and Kentucky.
Artemisia frigida Willd.
Idaho, Montana, Minnesota, Saskatchewan.
Menziesia glabella Gray.
Oregon, British Columbia, Bitterroot mountains, Flathead Lake, Mont. to Lake Superior.
Spiraea lucida Dougl. (= S. betulifolia Pall.).
British Columbia, Oregon, Montana, Black Hills.
Vaccinium membranaceum Dougl. (= V. myrtilloides Hook.).
Flathead Lake, Bitterroot mountains, Alaska, California, east to Lake Superior.

The following twenty six species of Pacific coast shrubs and trees range from California northward, but in Washington and Oregon, they turned eastward and entered the northern Rocky Mountains of the United States and British America, extending only, as far, as the Bitterroot Mountains in Idaho, perhaps in later glacial times when the floral intercommunication of the northern Cascades with the northern Rockies must have been very free.

Pinus albicaulis Engelm.
» monticola Dougl.
Alnus rhombifolia Nutt.
Artemisia discolor Dougl. var. incompta [Nutt.
Artemisia ludoviciana Nutt., Bitterroots.
Berberis nervosa Pursh, Bitterroots.
Cornus Nuttallii Audub., Bitterroots.
» pubescens Nutt., Bitterroots.

Crataegus columbiana Howell, Bitterroots.
» Douglasii Lindl.
Kalmia glauca L. var. microphylla Hook.
Pentstemon fruticosa Pursh. (= P. Menziesii Hook.), Bitterroots.
Populus trichocarpa Hook.
Rhamnus Purshiana DC.
Rubus leucodermis Dougl., Bitterroots.
Sambucus melanocarpa Gray, Bitterroots.
Salix sitchensis Sanson, Bitterroots.
Spiraea arbuscula Greene, Bitterroots.
Sorbus occidentalis Wats.
Taxus brevifolia Nutt.
Thuja plicata D. Don.
» gigantea Nutt.
Tsuga heterophylla Sarg.
» Pattoniana Engelm. (= T. Mertensiana Sarg.).
» Mertensiana Carr.
Vaccinium occidentale Gray.

The following species of the northern Rocky Mountains have a range northward:

Rhododendron (Azaleastrum) albiflorum (= Azalea albiflora Hook.).
Larix Lyallii Parl.
Rosa pisocarpa Gray, while eleven occur only in the Flathead Lake Region of Idaho and the Bitterroot Mountains, viz.
Alnus sinuata E. Regel.
Chrysothamnus (Bigelowia) graveolens Nutt.
Pentstemon mollis Sudw.
Ribes irriguum Dougl. (= R. divaricatum Dougl. var. irriguum Gray).
Ribes niveum Lindl. (= R. gracile Michx.).
Rubus parviflorus Nutt. (= R. nutkanus Michx.).
Rubus vitifolius Cham. & Schlecht. (= R. ursinus Cham. & Schlecht.).
Salix Nuttallii Sarg.
Vaccinium scoparium Leiberg.

The northeastern and eastern element entered in all probability by a path which crossed the northern end of the great plains and followed the eastern flank of the Rocky Mountains southward to Idaho and Montana, where the migration of this contingent seems to stop.

Abies balsamea Mill.
Alnus viridis DC. (= A. alnobetula Ehrh.).
Atragene americana Sims (= Clematis verticillaris DC.).
Betula papyrifera Marsh.
Bryanthus empetriformis Gray.
Crataegus macracantha Lodd. (= C. coccinea L.).
Picea alba Link (= P. canadensis B. S. P.).
Picea mariana B. S. P.
Populus balsamifera L.
Prunus virginiana L.
Quercus macrocarpa Michx.
Ribes Hudsonianum Richards.
» rotundifolium Michx.
Rosa blanda Ait.
Salix vestita Pursh.
Ulmus americana L.

The flora of the northern Rocky mountains is c l e a r l y a d e r i v a t i v e o n e, because *it occupies a territory* at *one time glaciated* and because the affinities of the plants clearly point to a western and eastern derivation and not a continuation of the flora *of the* southern *Rocky mountains*. Its characters are clearly negative and the forest flora is distinguished more by what is absent than by what is present. For example, it lacks very many of the peculiar

Pacific coast plants. It lacks almost entirely elements derived from the Great Basin region, as well, as many of the peculiar genera of the eastern, or Atlantic flora. There are, however, many plants restricted to this region which in all probability have been differentiated since the close of the glacial period.

The mountain systems south of the Bighorn valley, which we have chosen as a line of separation, may be denominated the southern Rocky mountain region. Its flora likewise possesses negative characters, but it is clearly distinct from the northern region by the injection of floral elements derived from Mexico and the Great Basin. The northwestern element in this flora is prominent having been in the process of diffusion from the beginning to the end of the last glacial recession, because to have entered the southern Rocky Mountains required a longer time than that subsequent to the final melting of the glaciers and the drying up of the lakes.

Acer glabrum Torrey.
Artemisia dracunculoides Pursh.
Berberis repens Lindl.
Celtis occidentalis L. var. reticulata
Clematis ligusticifolia Nutt. [Torr.
Crataegus rivularis Nutt.
Gaultheria myrsinites Hook.
Juniperus scopulorum Sarg.

Lonicera ciliosa Poir.
Ribes aureum Pursh.
» cereum Dougl. [Gray.
» divaricatum Dougl. var. irriguum
» oxyacanthoides L. var. saxosum
Rosa nutkana Presl. [Hook.
Salix chlorophylla Anders.
Sambucus glauca Nutt.

A number of other trees and shrubs may have entered the southern and northern Rocky Mountains of the United States and Canada by the northwestern route after the Glacial period, but more likely, they represent a relict flora of a period, when as species, they were more widespread during a more humid period before subjected to the arid climate which exists in the region at the present day. To be included in this category in all probability are:

Abies subalpina Engelm. (= A. lasiocarpa Nutt.).
Betula occidentalis Hook.
Picea Engelmanni Engelm.
Pinus Murrayana Balfour (= P. contorta var. Murrayana Engelm.)
» ponderosa Dougl.

Pseudotsuga Douglasii Carr. (= P. taxifolia Britt. = P. mucronata Sudw.).
Pyrus sambucifolia Cham. & Schlecht.
Salix flavescens Nutt.
» lasiandra Benth.
Sambucus melanocarpa Gray.
Tetradymia glabrata Gray.

The migrants which came down the Rocky Mountain system long subsequent to the great ice age out of the north and east from the eastern part of the continent and settled in the southern Rocky Mountain region are:

Alnus incana Willd. to Colorado.
Ampelopsis (Parthenocissus) quinquefolia Michx. to New Mexico.
Cornus canadensis L. to Colorado.
» stolonifera Michx. to Colorado.

Crataegus tomentosa L. to New Mexico.
Elaeagnus argentea Pursh. to Utah.
Fraxinus pubescens Lam. rare.
» viridis Michx. f. to Arizona.
Juniperus communis L. to New Mexico.

Juniperus nana Willd. to Colorado.
» virginiana L. to Colorado.
Kalmia glauca Ait. to Colorado.
Negundo aceroides Moench (= Acer Negundo L.).
Populus monilifera Ait. (= P. deltoides Marsh.).
» tremuloides Michx. to Colorado.
Prunus americana Marsh.
» pennsylvanica L. to Colorado.
Rhus glabra L. to Colorado.
» toxicodendron L. to Colorado.
Ribes cynosbati L. to Colorado.
» floridum L'Her. to Colorado.
» lacustre Poir. to Colorado.
» oxyacanthoides L. to Colorado.
Ribes prostratum L'Her. to Colorado.
Rubus strigosus Michx. to New Mexico.
Salix amygdaloides Anders.
» Bebbiana Sarg. (= S. rostrata Richardson) to Colorado.
» novae-angliae Anders. to Colorado.
» phylicifolia L. (= S. chlorophylla) to Colorado.
» reticulata L. to Colorado.
Sambucus canadensis L.
Symphoricarpos occidentalis Hook. to Colorado.
Vaccinium myrtillus L. to Colorado, Utah and northward to Alaska.
Viburnum pauciflorum Pylai.
Vitis riparia Michx. to Colorado.

A considerable number of shrubs have taken a northern route from the east and northeast across the continent, reaching the Pacific coast and California by way of Montana, Idaho and Washington and in some cases migrating southward through the Rocky Mountains. These transcontinental shrubs are:

Amelanchier alnifolia Nutt.
Arctostaphylos uva-ursi Spreng.
Betula glandulosa Michx.
Corylus rostrata Ait.
Juniperus sabina L. var. procumbens Pursh.
Lonicera coerulea Linn.
» involucrata Banks.
Physocarpus opulifolia Maxim.
Potentilla fruticosa L.
Rubus nutkanus Moç.
» occidentalis L.
Salix cordata Muhl.
» longifolia Muhl.
» rostrata Richards.
Sambucus racemosa L.
Shepherdia canadensis Nutt.
Spiraea betulifolia Pall.
Symphoricarpos racemosa Michx.
Vaccinium caespitosum Michx.

The central and southern Rocky Mountains harbor a considerable number of shrubs and trees which are confined to them, but which have either a wide extension north and south, or more restricted northern, central, or southern range. Those ligneous plants which extend from Montana to New Mexico and Arizona are:

Acer grandidentatum Nutt.
Picea Engelmanni Engelm.
Populus angustifolia James.
Rosa arkansana Porter.
Shepherdia argentea Nutt.

A small element consists of those plants which are confined to the central mountains:

Fraxinus anomala Torr.
Rubus deliciosus James.
Picea pungens Engelm.
Salix monticola Bebb.

while the following range from Colorado northward:

Alnus tenuifolia Nutt.
Ceanothus sanguineus Pursh.
Picea pungens Engelm.
Rosa Sayi Schwein.
Ceanothus ovatus Desf.
Pachystima myrsinites Raf.
Rhamnus alnifolia L'Her.
Salix candida Willd.
» desertorum Richards.
» irrorata Anders.
» glauca L. var. villosa Anders.
Tetradymia Nuttallii Torr. & Gray.

A Rocky mountain contingent of woody plants occurs from Colorado southward to New Mexico and Arizona, a few extending into Texas:

Ceanothus Fendleri Gray.
Forestiera neomexicana Gray, to Texas.
Prunus angustifolia Marsh.
Fendlera rupicola Eng. & Gray.
Philadelphus microphyllus Gray.
Quercus undulata Torr. var. Gambelii Engelm., to Texas.

The vegetation of the southern Rocky Mountains reaches its southeastern limit in the Cordilleran tableland of Texas, which includes the Stockton plateau and the Edwards plateau. The altitude in several instances is sufficient to increase the rainfall to nearly 20 inches, where the normal for that latitude is 15 inches. This and the fractured condition of the strata render these mountains capable of sustaining rather heavy timber of the southern Rocky Mountain type. There are large tracts also of high grass plains and scattered Mountain masses, with intervening undrained pockets ("bolson flats")[1]. The Edwards plateau is a common meeting ground for species from the Atlantic forests, from the southern Rocky Mountains and the Mexican highlands. The principal Rocky Mountain species, represented on this plateau, are *Pinus edulis*, *Quercus Emoryi*, *Juniperus (Sabina) sabinoides*, while isolated islands of the true mountain forest of *Pinus ponderosa*, *Pinus flexilis*, *Pseudotsuga Douglasii* (= *P. taxifolia* = *P. mucronata*), *Quercus Emoryi*, *Pinus edulis* are found limited to the Guadalupe, Davis and Chisos mountains.

*Great Basin Elements.* The Great Basin element consists of those plants which are widely distributed through the arid states of Arizona, New Mexico, Utah and Nevada, and which also extend to the Rocky Mountains, where they occur either sparingly, or relatively abundant. The range of each species in the list below, the Mexican element being marked with asterisk *.

*Acacia Greggii Gray.
Southern Utah, N. Mexico, Arizona, California, N. Mexico.
Ceanothus velutinus Dougl.
Colorado, Utah, Teton and Bitter-root Mountains.
Coleogyne ramosissima Torr.
Southern Colorado, Nevada, Arizona.
*Fraxinus pistaciifolia Torr.
Southern New Mexico, Arizona, Nevada, western Texas, Mexico.

1) Bray, William L.: Forest Resources of Texas. Bureau of Forestry U. S. Department Agriculture Bulletin No. 47. 1904: 11.

Jamesia americana Torr. & Gray.
New Mexico, Colorado, Utah.

Juniperus californica Carr. var. utahensis Engelm.
Central and Southern Utah, Nevada, California, Arizona.

Juniperus occidentalis Hooker var. monosperma Engelm.
Southern Colorado, N. Mexico, Southern Arizona, S. California.

Physocarpus Torreyi Maxim.
Colorado to Nevada.

Pinus Balfouriana Murray var. aristata Engelm. (= P. aristata Engelm.)
Colorado, Utah, Nevada, S. E. California.

Pinus monophylla Torr. & Fremont.
Utah, California, Arizona.

*Prosopis juliflora DC.
Southern Colorado, New Mexico, Southern California, western Texas, Southern Utah, Mexico.

*Prosopis pubescens Benth.
New Mexico, western Texas, Arizona, California, Mexico.

Sarcobatus vermiculatus Torr.
Southern Wyoming, Great Basin, to the Upper Missouri River.

Another group of Rocky Mountain trees and shrubs, if we admit those occurring in New Mexico and Arizona, are those which in all probability have had their origin in Mexico, or the arid region of New Mexico, Arizona and southern California and have either remained near their primitive seat, (A) or have migrated northward from this common center along the Rocky Mountains, (B) or through California and the Rocky Mountains simultaneously (C). In the Rocky Mountains these elements may be classed together, as the Mexican, or southwestern contingent of the flora. In all probability, this migration took place just before the final recession of the glaciers from the mountains and when the great interior lakes Bonneville and Lahontan had shrunken extensively in size with the gradual approach of an arid climate. In each case, the range of the species is given in the list which follows. Those marked by an asterisk are known to occur in Mexico.

**A.** Acacia millefolia Wats. Arizona.
*Alnus oblongifolia Torr. Arizona, New Mexico, California.
Canotia holacantha Torr. Arizona on dry plateaus.
*Chilopsis saligna D. Don. Southern Arizona.
*Cowania mexicana Don. New Mexico, Colorado, Utah, N. Mexico.
Condalia obovata Hooker. Southern New Mexico, Arizona.
Cupressus guadalupensis Watson. Southern New Mexico and Southern Arizona and southward.
*Juniperus pachyphloea Torr. Southern Arizona, New Mexico, Texas, Mexico.
*Morus microphylla Buckl. Mountain canyons of Southern New Mexico, also in western Texas and Mexico.
Pinus chihuahuana Engelm. Southwestern New Mexico extending into Arizona.
Pinus reflexa Engelm. Southwest New Mexico and southeast Arizona.
*Platanus Wrightii Wats. Mountain canyons southwestern New Mexico, in southeastern Arizona and Mexico.

*Ptelea angustifolia Benth. through Colorado, Mexico and Texas.
Prunus capsuli Cav. (= P. capollin Zucc.). Through Arizona, New Mexico, western Texas.
Quercus Emoryi Torr. Southern New Mexico, Arizona, western Texas.
*Quercus hypoleuca Engelm. High mountain ranges southwestern New Mexico, Santa Rita Mountains, southeastern Arizona, Sonora.
*Quercus oblongifolia Torr. Southern Arizona, New Mexico, Mexico.
Sophora secundiflora Lagasca. New Mexico to Gulf coast of Texas.
*Ungnadia speciosa Endl. New Mexico (western Texas and northern Mexico).
*Yucca elata Engelm. Western Texas, to Utah, Mexico.

**B.** Artemisia tridentata Nutt. Colorado to southwest, Bitterroots.
Baccharis salicina Torr. & Gray. Colorado to Texas.
Berberis Fendleri Gray. Southern Colorado southward, westward to Southern California.
Eupatorium ageratifolium DC. Southern Colorado to Texas.
Juniperus monosperma Engelm. Colorado and California.
Larrea mexicana Moric. Southern Colorado to California also in Texas.
Pinus aristata Engelm. Colorado and Death Valley Region.
Pinus edulis Engelm. Southern Colorado, New Mexico, western Texas.
Populus Fremontii Wats. var. Wislizeni Wats. Southern Colorado, New Mexico, western Texas, Arizona, Southern California.
Purshia tridentata DC. Rocky Mountains, Arizona, to Southern California.
*Quercus grisea Liebm. Southern Colorado; Southern New Mexico, westward through Southern Arizona, California, N. Mexico.
*Robinia neo-mexicana Gray. Southern Colorado, southwestern and western New Mexico, Arizona, Southern Utah.
Rhus trilobata Nutt. Colorado and southwest to southern California.
*Yucca baccata Torr. New Mexico to southern Colorado, westward into Southern California, southward into northern Mexico.

**C.** Abies concolor Lindl. and Gord. New Mexico, southern California to Oregon, Colorado.
Cercocarpus ledifolius Nutt. Arizona, New Mexico, western Montana, Idaho and on Pacific coast Southern California to Washington.
Cercocarpus parvifolius Nutt. Arizona, New Mexico, Wyoming; also in California.
Holodiscus discolor Maxim. New Mexico, Colorado, Bitterroot Mountains, Pacific coast.
Juglans rupestris Engelm. Southern New Mexico, western Texas, Arizona, Pacific coast to central California.
Peraphyllum ramosissimum Nutt. Southwestern Colorado, Utah, California and Oregon.
Rhamnus californica Esch. Southwestern Colorado, New Mexico, California and north to the valley of the upper Sacramento.
Ribes lepanthum Gray. Colorado, New Mexico, sierras of California.

Ribes sanguineum Pursh. Colorado and California.

Rosa Fendleri Crép. New Mexico, western Texas, sierras of California, and northward beyond boundary.

Symphoricarpos oreophilus Gray. Colorado, Utah, Arizona, California and Oregon.

Tetradymia canescens DC. New Mexico to northern Wyoming, Arizona, California, British Columbia.

Tetradymia spinosa Hook. & Arn. Southern Wyoming to Arizona, southeastern California and eastern Oregon.

Two plants have entered the Rocky mountain region from the southeast, viz., *Rhamnus caroliniana* Walt. which ranges from Montana through Colorado western Texas, northern Florida and northeastward to Long Island, New York, and *Sapindus marginatus* Willd. from southern New Mexico and Arizona, eastward through the Gulf States to the Atlantic coast.

3. *Origin of Alpine and Boreal Floras of Western America*[1]. Before considering the origin of the flora of the Great Basin, which now concerns us, it is important to study the origin of the alpine and boreal floras of the mountains of western North America, which consist of first, the Rocky Mountains, and second, the Sierra Nevada and Cascade ranges. As, from what follows, the origin of the boreal floras of these mountains can be traced to the same source, it is expedient at this juncture to tabulate the boreal plants of a common origin and group them according to the mountain ranges on which they are found. This will simplify matters, so that when the general floral development of the Sierra Nevada and Cascade ranges is described, a consideration of the boreal floras of these mountains can be illiminated from the discussion.

The two great mountain ranges at their southern ends are widely separated by the deserts of the Great Basin; but in British Columbia the two systems draw closer together, the depressed plains between them become studded with other mountains, and the cold of the northern latitude allows the boreal flora of the mountain crests to descend more nearly to the base level of the country. Under these conditions, we should expect the boreal flora of any portion of one system to be most nearly similar to that of other portions of the same system; and, indeed, that each system would constitute a distinct line of southward boreal migration and a distinct center for the differentiation of new forms distinct from their progenitors, the migrating boreal species. The following list adapted from COVILLE[2] with the addition of the northern Sierran plants constitutes a fair representation of the boreal Sierran flora which has been separated into four groups: **a)** those confined to the Sierra Nevada; **b)** those common to the Sierra Nevada and Cascade Mountains only; **c)** those common

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1) See the foregoing page 243.

2) COVILLE, FREDERICK VERNON: Botany of the Death Valley Expedition Contributions from U. S. National Herbarium IV: 27—29. 1893.

to the Sierra Nevada and Rocky Mountains only; and **d)** those common to the Sierra Nevada, Cascade Mountains and Rocky Mountains.

**a)** Confined to the Sierra Nevada.

Arabis platysperma Gray.
Arctostaphylos nevadensis Gray.
Arenaria compacta Coville.
Artemisia Rothrockii Gray.
Aster Andersonii Gray.
Bigelovia Bolanderi Gray.
Bryanthus Breweri Gray.
Chrysopsis Breweri Gray.
Crepis intermedia Gray var. pleurocarpa Gray.
Draba Lemmoni Wats.
Epilobium obcordatum Gray.
Erysimum asperum Nutt. var. perenne
Eulophus Parishii C. & R. (Wats.
Gentiana serrata Gunn var. holopetala Gray.
Hemizonia Wheeleri Gray.
Hulsea algida Gray.
Leucothoe Davisiae Gray.
Lupinus Breweri Gray.
Lychnis californica Wats.
Orochaenactis thysanocarpa Gray (Chaenactis in part).
Oreobroma nevadensis Gray.
Pedicularis attollens Gray.
Montia fontana L.
Bryanthus (Phyllodoce) Breweri Gray.
Potentilla santolinoides Baill.
» Wheeleri Wats.
Primula suffrutescens Gray.
Quercus vacciniifolia Kell. (= Q. chrysolepis Liebm. var. vacciniifolia Engelm.).
Raillardella argentea Gray.
Ranunculus oxynotus Gray.
Salix macrocarpa Nutt. var. argentea
Saxifraga bryophora Gray. (Bebb.
Silene bernardina Wats.
» californica Dur.
Streptanthus tortuosus Kell.
Velaea vestita Wats.
Tanacetum canum Eaton.

**b)** Common to the Sierra Nevada and Cascade Mountains only.

Allotropa virgata Torr. & Gray.
Carex Breweri Booth.
Claytonia triphylla Wats.
Salix Barclayi Anders.
Gentiana Newberryi Gray.
Juncus orthophyllus Coville.
Lonicera conjugialis Kell.
» involucrata Banks.
Potentilla glandulosa Lindl. var. nevadensis Wats.

**c)** Common to the Sierra Nevada and Rocky Mountains only.

Alsine baicalensis Coville (= Stellaria umbellata Turcz.).
Carex incurva Lightf.
Gilia Nuttallii Gray.
Helenium Hoopesii Gray.
Luzula (Juncoides) spicatum Desv.
Navarretia (Gilia) Breweri Gray.
Polemonium confertum Gray.
Potentilla procumbens Sibth.
Swertia perennis L.
Pinus flexilis James.
Scirpus pauciflorus Lightf.

**d)** Common to the Sierra Nevada, Cascade Mountains, and Rocky Mountains.

Alsine longipes Goldie.
Antennaria dioica Gaertn.
Arabis hirsuta Scop.
Arnica Chamissonis Less.
Crepis nana Rich.
Carex aurea Nutt.

Carex festiva Dewey.
» filifolia Nutt.
» tenella Schkuhr.
Claytonia Chamissonis Esch.
Deschampsia caespitosa Beauv.
Draba stenoloba Ledeb.
Epilobium anagallidifolium Lam.
Erigeron compositus Pursh.
» salsuginosus Gray.
» uniflorus L.
Festuca ovina L. var. brevifolia Wats.
Glyceria pauciflora Presl.
Heuchera rubescens Torr.
Saxifraga punctata L.
Spraguea umbellata Torr.
Trifolium longipes Nutt.
Valeriana silvatica Rich.
Juncus Parryi Engelm.
» subtriflorus E. Mey.
Mitella pentandra Hook.
Phleum alpinum L.
Phlox Douglasii Hook.
Polygonum bistortoides Pursh (= P. bistorta L.).
Pulsatilla occidentalis Wats.
Rumex Geyeri Meisn.
Saxifraga nivalis L.
Sedum roseum L. (= S. rhodiola DC.).
Tellima tenella Nutt.
Trisetum subspicatum Beauv.

It appears from this list, that nearly one half are common to the three regions, a fact which emphasizes the community of origin of all our boreal vegetation. About one-third of the whole number are confined to the Sierra Nevada. This is a large percentage for the endemic constituent of any region which climatically so closely resembles other portions of the same continental area. The broad geographic isolation of the Sierra Nevada, and the great antiquity of this isolation may explain the phenomenon in question. These lists indicate that the flora of the higher Sierra Nevada of California has an affinity quite as close with that of the Rocky Mountains of Colorado, as with that of the Cascade mountains of Oregon and Washington. In suggesting a reason for this remarkable fact, we must consider the theoretic cause of their original migration.

Several glacial periods are recognizable in North America, when the continental ice sheet advanced and then retreated, giving rise to one or two interglacial periods, when the surface exposed by the retiring ice was rapidly occupied by vegetation, which for example in many places in Iowa, Minnesota formed accumulations of peat sometimes to the depth of 25 feet. It was probably during the first stage in the advance of the continental ice sheet, that the first contingent of boreal plants migrated along the Cordilleran system of mountains southward. For in all probability, this stage was not one of maximum glaciation, but one in which only the mountain glaciers existed giving rise to conditions favorable for the rapid advance of many boreal plants. Consequent on the first retreat of the glacial ice and the ushering in of the first interglacial period, this vanguard of boreal plants remained stranded on the mountain summits of the Sierra Nevada, Cascade and Rocky Mountains and during this period of isolation, they were modified into the forms which are confined to these mountains and which characterize them floristically speaking. To this category belong the plants listed under divisions **a** and **b** above.

The advent of the later glacial advances inaugurated a change of climate and a more general refrigeration of the northern part of North America. Not only were the mountain valleys filled with glaciers descending from the mountain tops, but the larger valleys themselves with the lower mountain peaks between had their temperature so reduced as to permit the migration of boreal plants into and across them. It was during the period of maximum glaciation, that a second contingent of boreal plants reached the cordilleran system of mountains south of the extremity of the ice sheet. These plants, however, in reaching the Sierra Nevada Mountains evidently did not descend through the Cascade ranges (although some of them did move down these mountains, but not from them into the Sierras), but through the Rocky Mountains. To explain the distribution of groups **c** and **d**, we must assume a means of communication between the floras of the Sierra Nevada and those of the southern Rocky Mountains shortly before their final separation. It is believed that this communication may easily have taken place across Nevada and Utah by way of the numerous mountain ranges which traverse those regions. Under their present conditions of isolation, the migration of these species would be impossible; but when the present boreal flora was depressed nearly or quite to the base level of the mountains an excellent route for migration was presented. This explanation is rendered still more probable by the occurrence of nearly all the species of group **c** upon one or more of the higher desert ranges, such as the White, East Humboldt and Trinity mountains of Nevada, and the Uinta and Wahsatch mountains of Utah [1]).

The plants of group **d** also advanced during the period of maximum glaciation reaching simultaneously, the Cascade Mountains, and the Rocky Mountains and from the latter by the route mentioned above to the Sierra Nevada Mountains proper.

The explanation of the circuitous route taken by the boreal plants of the second migration to the Sierra Nevada Mountains is afforded by a study of the distribution of species on Mount Shasta. MERRIAM [2]) has pointed out that the Klamath River Valley is the efficient barrier that must be considered in the distribution of boreal species. Klamath Gap represents a break of less than 50 miles separating the boreal fauna and flora of Shasta from that of the Cascades. In studying this gap compared with the breadth of the combined Pitt River and Feather River gaps, about 100 miles separating Mount Shasta from the boreal elements of the Sierra Nevada northwest of Honey Lake, one might expect Shasta to share more species with the Cascades than with the Sierras. The contrary is true. Of the distinctively Cascade species 25 per cent are derived from the mountains farther north, 12 per cent are local types, 12 per cent belong to transcontinental boreal types, and

1 COVILLE, F. V.: Botany of the Death Valley Expedition. Contributions U. S. National Herbarium IV: 30. 1893.

2) MERRIAM, C. HART: Results of a biological Survey of Mount Shasta California. North American Fauna, No. 16: 86. 1899.

25 per cent to northwest coast-types[1]). Of the distinctively Sierra species, 50 per cent are especially developed local types, and 50 per cent belong to types common to the Sierra and the southern Rocky Mountains. These facts point not only to the great antiquity and effectiveness of the Klamath Gap, but also to a former east and west continuity of boreal species between the Rocky Mountains of Utah and Colorado and the Sierra Nevada of California, a distance of at least 500 miles.

The following lists of plants will represent the relationships of the boreal-alpine flora of Mount Shasta, the Cascade range and the Sierra Nevada Mountains. In giving these lists, a characterization of the different regions is also established.

**a)** Boreal-alpine species common to Shasta and the Sierra-Cascade System.

Achillea borealis Bong. (= A. millefolium L.).
Aconitum columbianum Nutt. (= A. Fischeri Reichb.).
Allium validum Wats.
Alnus sinuata E. Regel.
Antennaria media Greene.
Arabis platysperma Gray.
Arctostaphylos nevadensis Gray.
Dicentra (Bicuculla) uniflora Kell.
Cardamine bellidifolia L. var. pachyphylla Coville.
Carex Breweri Boot.
Chimaphila Menziesii Spreng.
» umbellata Nutt.
Chrysothamnus Bloomeri Gray.
Cymopterus terebinthinus Torr. & Gray.
Drosera rotundifolia L.
Epilobium obcordatum Gray.
» Pringleanum Hausskn.
Eriogonum pyrolaefolium Hook.
Gentiana simplex Gray.
Habenaria leucostachys Wats.
» unalaschkensis Wats.
Holodiscus discolor Maxim.
Juncus Parryi Engelm.
Kalmia glauca L. var. microphylla Hook.
Mimulus primuloides Benth.
Mitella pentandra Hook.
Oreobroma triphylla Wats. (= Claytonia triphylla Wats.).
Orthocarpus pilosus Wats.
Oxyria digyna Campd.
Pentstemon Newberryi Gray (= P. Menziesii Hook.).
Phlox Douglasi Hook. var. diffusa Gray.
Polemonium pulchellum Bunge (= P. humile Willd.).
Polygonum shastense Brewer.
Potentilla flabellifolia Hook. (= P. gelida C. A. Meyer).
Pulsatilla occidentalis Wats.
Pyrola picta Sm.
Sagina saginoides L. (= S. Linnaei Pursh).
Saxifraga Tolmiei Torr. & Gray.
Sibbaldia procumbens L.
Sorbus sambucifolia Roem. (= Pyrus sambucifolia Cham. & Schlecht.).
Spraguea umbellata Torr.
Viola blanda Willd.
» purpurea Kell. (= V. aurea Kell. var. venosa Wats.).

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1) Merriam l. c. p. 82—86.

**b)** Boreal and alpine species common to Shasta and the Sierra but not known from the Cascades.

Agoseris monticola Greene.
Arnica *Merriami* Greene.
Castilleja affinis Hook. & Arn.
Chaenactis nevadensis Gray.
Cheiranthus perennis Coville.
Corallorhiza Bigelovii Wats.
Crepis intermedia Gray.
Cycladenia humilis Benth.
Draba Breweri Wats.
Erigeron armeriaefolius Turcz.
» compositus var. trifidus Hook.
Eriogonum polypodum Small.
Hieracium albiflorum Hook.
Hieracium horridum Fries.
Hulsea Larseni Gray (= H. nana Gray var. Larseni Gray).
Madia Bolanderi Gray.
Parnassia californica Gray.
Saxifraga bryophora Gray.
Senecio canus Hook.
» trigonophyllus Greene.
Stellaria crispa Cham. & Schlecht.
Streptanthus orbiculatus Greene.
Vaccinium caespitosum Michx.
Smilacina (Vagnera) stellata Desf.
Veratrum californicum Dur.

**c)** Boreal and alpine species common to Shasta and the Cascades but not known from the Sierra.

Abies shastensis Lemm. (=A. magnifica Murr. var. shastensis Lemm.).
Epilobium clavatum Trelease.
Hieracium gracile Hook. (= H. triste var. gracile Gray).
Hulsea nana Gray.
*Ligusticum Grayi Coult. and Rose.*
Lupinus ornatus Dougl.
Spiraea (Lutkea) pectinata Torr.&Gray.
Machaeranthera (Aster) shastensis Gray.
Oreastrum (Aster in part) alpigenum Torr. & Gray.
Pentstemon Menziesi Hook.
Bryanthus (Phyllodoce) empetriformis D. Don.
Polygonum Newberryi Hook.
*Silene Suksdorfi Robinson.*
Tofieldia occidentalis Wats.
Veronica Cusickii Gray.

**d)** Boreal Shasta species not known from either the Sierra or the Cascades [1]. Peculiar to Shasta.

Arnica longifolia Eaton.
» *viscosa Gray.*
Campanula Wilkinsiana Greene.
Mimulus implexus Greene.
Pentstemon glaber Pursh var. utahensis Wats.
*Phacelia frigida Greene.*
Scutellaria nana Gray.
Silene Grayi Wats.

**e)** Boreal genera and species common to the Sierra and the Cascades, but not known from Shasta.

Genera not known from Shasta.

Arenaria.
Cassiope.
Claytonia.
Clintonia.
Erythronium.
Heuchera.
Iris.
Ivesia.
Listera.
Mertensia.
Pedicularis.
Primula.
Raillardella.
Ranunculus.
Smelowskia.
Streptopus.
Thalictrum.
Xerophyllum.

1) MERRIAM l. c.

Species not known from Shasta.

| | |
|---|---|
| Arnica Chamissonis Less. | Lonicera involucrata Banks. |
| Campanula Scouleri Hook. | Polygonum bistortoides Pursh. (= P. bistorta L.). |
| Crepis nana Rich. | Populus tremuloides Michx. |
| Erigeron salsuginosus Rich. | Salix Barclayi Anders. |
| Gentiana Newberryi Gray. | Saxifraga nivalis L. |
| Juncus orthophyllus Coville. | Saxifraga punctata L. |
| Lonicera conjugialis Kell. | |

**f)** Boreal Sierra species not known from Shasta or the Cascades. (See table adapted from COVILLE. Ante page 254 sub a.)

**g)** Boreal Cascade species not known from Shasta or the Sierra.

| | |
|---|---|
| Gaultheria myrsinites Hook. | Ribes erythrocarpum. |
| Menziesia ferruginea Smith. | Ribes lacustre Pir. |
| Rubus lasiococcus Gray. | Valeriana sitchensis Bong. |
| Silene acaulis L. | Sorbus occidentalis Wats. |
| Rhododendron (Azaleastrum) albiflorum Hook. | Spiraea arbuscula. |
| | Vaccinium microphyllum Reinw. |

The tabulation of the species here presented may serve to illustrate the fact, that a circumpolar boreal plant, if it occurs in North America at all is usually found over broad areas, or at widely separated points. This principle is supported by the fact that the group of species common to all three mountain ranges contain some that are circumpolar while those that are common to one, or at most two ranges include not a single circumpolar species. Several of these circumpolar species are found also in the high mountains of the Atlantic side of the continent. This indicates that the present boreal flora was at one time diffused over the base level of a large transverse zone south of the Canadian line; in other words the flora of the north in glacial times was far more homogeneous in an east and west direction than our present flora. Finally, our two great western mountain systems do not show marked isolation, as a group, but each has a well-defined individual isolation. Of the species common to the Sierra Nevada, Cascade Mountains and Rocky Mountains, nearly one-half are also either Alaskan, or circumpolar; while the number of those common to the three ranges and confined within them is less than the number confined to the Sierra Nevada alone [1]).

Attention must be called to the glacial meadows of the high Sierras, because they are covered with many plants which enter largely into the composition of the flora. The glacial meadows are smooth, level, silky lawns, lying imbedded in the upper forests, on the floors of the valleys, and along the broad backs of the main dividing ridges, at a height of about 8000 to 9500 feet above the sea. They are nearly, as level, as the lakes whose places

1) COVILLE, F. V. l. c. p. 30.

they have taken, and present a dry, even surface free from rock-heaps, mossy bogginess, and the roughness of rank, coarse-leaved, weedy and shrubby vegetation. The soil, is close and fine, and so complete that you cannot see the ground and with its vegetation, it may be likened to a garden-meadow, or meadow-garden. Glacial meadows abound throughout the alpine and subalpine regions of the Sierra in still greater numbers than the lakes. Probably from 2500 to 3000 exist between the latitude 36° 30′ and 39° distributed like the lakes in concordance with all the other glacial features of the landscapes. There are big meadows usually about five to ten miles long. These occupy the basins of the ancient ice-seas, where many tributary glaciers came together to form the grand trunks.

The historic development of the flora of these areas has been, as follows. With the retreat of the ice, a lake was formed, later to be surrounded by tree vegetation. The lake, if large, slowly filled with silt and aquatic plants; if small, more rapidly. A bog resulted by the filling process and bog associations appeared and as the ground became drier and more compact, the meadow species, last in point of time to arrive, covered the area of the former lake basin. The culmination, however, is reached when the meadow plant associations are finally driven out by the encroachment of tree vegetation. All of the vegetation of these areas, then, is subsequent to a period marked by the present of extensive glaciers, which during a period of refrigeration covered all of these mountain summits. In these meadows, species of such genera, as *Gentiana*, *Ivesia*, *Orthocarpus*, *Solidago*, *Pentstemon*, *Trifolium*, *Calamagrostis*, *Bromus*, *Agrostis*, *Triticum* abound with mosses on the ground, *Hypnum*, *Dicranum*, *Polytrichum*.

Hanging meadows found aslant upon moraine-covered hillsides trending in the direction of greatest declivity occur in the alpine and subalpine regions in considerable numbers. Such plants, as *Veratrum album*, *Aquilegia*, *Senecio*, *Allium*, *Castilleja*, *Delphinium*, *Lilium*, *Lupinus*, *Mimulus* and *Pentstemon* form a rich vegetal growth with brilliant flowers. These hanging meadows are likewise subsequent to the glaciers for they occur on glacial deposits, morainic material and the like [1]).

The eastern slopes of the Sierra Nevada Mountains are forest clad in a great measure; while the western slopes bear the noblest and most remarkable forest of the world. It is remarkable not only for the number of species of evergreen trees occupying a comparatively narrow area, but especially for their wonderful development in size and height. There is no forest to be compared for grandeur with that which stretches, essentially unbroken, though often narrowed and nowhere very wide, from the southern part of the Sierra Nevada in latitude 36° to Puget Sound beyond latitude 49°. The forest, separated by the valley of California, resumes sway in the Pacific coast ranges with altered features. The redwoods of the coast for instance

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1) Cf. MUIR, JOHN: The Mountains of California. 1901: 98—138.

are little less gigantic than the big trees of the Sierra Nevada, and a thousand times more numerous. Through most of California, these two Pacific forests are distinct but in the northern part of that state, they join and form one rich woodland belt skirting the Pacific and extending through British Columbia into Alaska. To these forests, we must now turn our attention.

ASA GRAY long ago called attention to the fact that the Pacific forest has no Magnolias, no tulip-tree, no linden and is very poor in maples; no locust trees, nor any leguminous trees; no cherry large enough for a timber-tree, like the eastern wild black cherry; no gum trees (*Nyssa*, nor *Liquidambar*), nor sorrel-tree, nor *Kalmia*, no persimmon or *Bumelia*; not a holly; only one ash that may be called a timber-tree; no catalpa or sassafras; not a single elm or hackberry; not a mulberry, nor planer-tree, nor *Maclura*; not a hickory nor a beech, nor a true chestnut, nor a hornbeam; barely one birch tree, and that only far north, where the differences are less striking. But as to coniferous trees, the only missing type is the eastern *Taxodium distichum*[1]).

## 5. Flora of the Pacific Mountain Ranges.

*General Remarks.* The Pacific forest consists of conifers, with non-coniferous trees as an occasional undergrowth, or as scattered individuals, and conspicuous only in valleys, or in the sparse tree-growth of the plains, on which the oaks form open groves. This predominance of coniferous vegetation is remarkable and paradoxic. The Pacific coast is the sole refuge of the most characteristic and wide-spread types of Miocene coniferae, the sequoias. Any attempted explanation of this extreme paucity at present of broad-leaved trees, which existed in the form of magnolias, beeches, chestnuts, elms and gums *Liquidambar* down to the beginning of the glacial period as shown by remains in the auriferous gravels of the west, bristles with difficulties. Much may be attributed to glaciation; something to the tremendous outpours of lava; much to the narrowness of the forestbelt, to the want of a summer rain, and to the most unequal and precarious distribution of that of winter. The coniferous trees essentially xerophytic in constitution were better able to survive when subjected to a combination of such influences, while the broad-leaved trees typic of the Miocene forest succumbed when exposed to the conditions which the conifers were able to resist. This suggests that the difference between the forests of the east and west is to explained by the climatic and other conditions which existed during and at the close of the great ice age, when the conditions which preserved the broad-leaved species of the east were exactly the reverse of those which in the Pacific coast brought about their extinction and the preservation of the coniferous vegetation, which is there dominant at the present day.

The following Pacific coast trees have migrated into the Rocky Mountain region and some have entered from the south (see ante).

1) GRAY, ASA: Forest Geography and Archaeology. Americ. Journ. Science and Arts XVI. 1878.

Pinus monticola Dougl.
» flexilis James.
» albicaulis Engelm.
» Balfouriana Murr.
» aristata Engelm.
» arizonica Engelm.
» ponderosa Laws.
» chihuahuana Engelm.
» Murrayana Oreg. Com. (= P. contorta var. Murrayana Engelm.).
Larix occidentalis Nutt.
» Lyallii Parl.
Picea Engelmanni Engelm.
Tsuga Mertensiana Bong. (= T. heterophylla Sarg.).
» Pattoniana Jeffr. (= T. Mertensiana Sarg.).
Pseudotsuga Douglasii Carr. (= P. mucronata Nutt., = P. taxifolia Poir.).
Abies subalpina Engelm. (= A. lasiocarpa Nutt.).
Abies concolor Lindl. & Gord.
Thuja plicata Don.
Juniperus occidentalis Hook.
» californica Carr.
Taxus brevifolia Nutt.
Salix amygdaloides Anders.
» lasiandra Benth.
» fluviatilis Nutt.
» sitchensis Sanson.
Populus trichocarpa Torr. & Gray.
Betula occidentalis Hook.
Alnus rhombifolia Nutt.
Prunus emarginata Walp.
Acacia Greggii Gray.
Acer glabrum Torr.
Cornus Nuttallii And.
Arbutus Menziesii Pursh.
Chilopsis saligna Don.
Sambucus glauca Nutt.

Many of these trees such as *Pinus ponderosa*, *Pseudotsuga Douglasii* form an important element in the Pacific coast region reaching their greatest size there. The enumeration above proves that the Rocky Mountains are comparatively poor in the size of its trees and the number of species; that few of the species are peculiar, and those mostly in the southern part, and of the Mexican plateau type; that most of the Rocky Mountain trees are identic in species with those of the Pacific forest. The Pacific forest in the widest sense extends from central Alaska southward.

*Alaska Forests.* The Alaska forest has a simple composition, for the bulk is made up of a mixture of two species, *Picea sitchensis* and *Tsuga Mertensiana* (*T. heterophylla*), with which dominant trees occur: *Pinus contorta*, *Abies subalpina* (*A. lasiocarpa*), *Alnus oregana*, *Acer glabrum*, *Populus balsamifera*, *Thuja gigantea*, *Cupressus* (*Chamaecyparis*) *nootkaensis*, while near the timberline and farther west, on the lower level grows *Tsuga Pattoniana* (*T. Mertensiana*). Numerically the coast hemlock seems to be the most common species forming usually 70 to 80 per cent of the composition of the forest, the spruce only occasionally preponderates, especially along water-courses and on newly forested moraines, until the western limit of the hemlock is reached at Prince William Sound. Farther west, the spruce alone continues to form forests or open groves, as on the shores of Cook Inlet and Kadiak Island, the western limit of tree growth.

Why trees are limited at this point, it is difficult to say for the rainfall is ample and the climate a little more severe than at Sitka. Perhaps two causes

have been influential. One explanation based on the historic development of the flora here is that the northward migration of coniferous and other trees on the Pacific coast has been checked by the long persistence of numerous local valleys glaciers which descend from the mountains to the sea. Another explanation advanced by FERNOW [1]) seems plausible in addition to the reason given above. The Alaska peninsula and Aleutian islands show evidence that they are of recent and volcanic origin. A forest could come to them only from the east, or northeast, by the gradual extension of the coast forest. To secure this extension, it is necessary that the winds should blow from the north and east from September to May, when the spruce and hemlock release their seed. The contrary usually happens; there is during these months a constant succession of southeast and south winds and the air is heavily charged with moisture bad for wind blown seeds. For these reasons, the spread of the forest has been retarded.

*Cascade- and Coast ranges.* This forest of Aláska is a continuation of the great maritime forest of north-western America, which at the south embraces the redwoods of California and spreads over western Oregon and Washington. This forest resembles the forest of Puget Sound and of western British Columbia, but it lacks *Pseudotsuga Douglasii* (*P. taxifolia*), the most abundant tree about Puget Sound, *Abies grandis* and *Acer macrophyllum* abundant in all the coast region further south. It represents historically and floristically a forest extension which began with the final recession of the great ice sheet and has continued ever since [2]).

At Puget Sound the character of the forest, although due to coniferous trees, owes its individuality to new species, which appear and which probably represent the northwestern fragment of that great forest which covered North America in Miocene times with the extinction of the majority of broad leaved trees. In the Puget Sound region, where the Cascade and Coast ranges join, we find the following trees to make up a forest which for denseness and size of its individual trees stand unrivalled.

East and southeast of Puget Sound in a territory well watered by streams are the Washington and the Mount Rainier national forests. In these national forests have been noted the trees given in the table below. (* in the Rainier and not in the Washington).

Pseudotsuga Douglasii Carr. (= P. taxifolia Poir. = P. mucronata Sudw.). Bench lands of the valleys and lower mountain slopes.

Thuja plicata Don. River bottoms to lower mountain slopes.

1) FERNOW, B. E.: The Forests of Alaska. Forestry and Irrigation. VIII: 70. Feb. 1902.

2) The vegetation of the northwest coast region is probably nowhere more highly developed than in the Queen Charlotte islands of the coast of Brit. Columbia. Of coniferous trees at least seven species are found, viz., Picea sitchensis, Tsuga heterophylla, Tsuga Mertensiana, Thuja plicata, Chamaecyparis nootkaënsis, Pinus contorta and Taxus brevifolia.

Tsuga Mertensiana Bong. (= T. heterophylla Sarg.).
Common up to 4000 feet.
Tsuga Pattoniana Jeffr. (= T. Mertensiana Sarg.).
Common up to 4000 feet.
Cupressus (Chamaecyparis) nootkaensis Lamb.
Mountain slopes above 2000 feet.
Picea sitchensis Carr.
Along streams up to an altitude of 2000 feet.
Picea Engelmanni Engelm.
High altitudes.
Abies amabilis Forb.
On moist land and northern slopes up to 4000 feet.
*Abies nobilis Lindl.
Rainier Forest.
*Abies concolor Lindl. & Gord.
Rainier Forest.
Abies subalpina Engelm. (= A. lasiocarpa Nutt.).
On higher slopes and summit.
Pinus monticola Dougl.
Medium altitudes, or bench lands and lower mountain slopes.
Pinus ponderosa Laws.
Dry slopes of the Skagit Valley north of Lightning Creek.
Pinus Murrayana Oreg. Com. (= P. contorta var. Murrayana Engelm.).
Dry bench lands northward to international boundary.
Pinus albicaulis Engelm.
High altitudes.
Larix Lyalli Parl.
Summit Cascade Range northward
*Larix occidentalis Nutt.
Rainier Forest.
Taxus brevifolia Nutt.
Common as an under tree on moist lands up at an altitude of 3000 feet
Populus trichocarpa Hook.
Common along streams in lower altitudes.
Cornus Nuttallii Audub.
On bench land in lower altitudes.
Pyrus (Malus) rivularis Dougl.
Common on low wet land.
Populus balsamifera L.
Occurs sparingly on the upper Skagit and eastward.
Populus tremuloides Michx.
Northward and eastward in the Skagit drainage.
Betula papyrifera Marsh.
In the Skagit Valley; abundant above Ruby Creek, rare below.
Acer macrophyllum Pursh.
Along streams below 2000 feet.
Acer circinatum Pursh.
Common below 3000 feet.
Alnus oregana Nutt.
Common along streams in lower altitudes.
Fraxinus Oregana Nutt.
Rainier Forest.
Quercus Garryana Dougl.
Rainier Forest.
Rhamnus Purshiana DC.
Common on moist land in lower valleys as a small under tree.

The trees noted in the list[1]) are also dominant west of Puget Sound in the Olympic Mountains, which rise from the Pacific Ocean, so that the above species may be said to represent the forest vegetation of the northwest above

1) AYRES, H. B.: Washington Forest Reserve. Nineteenth Annual Report United States Geological Survey 1897—98: 283.

the point where the forest is separated into two southward projecting lobes, the one on the coast, the other following the Cascade-Sierra ranges of mountains.

The forest of the Cascades is overwhelmingly coniferous. This is especially the case on the areas east of the Cascades, where broad leaved species of trees form but a fraction of 1 per cent of the forest growth, and where two conifers *Pinus ponderosa* and *Pinus Murrayana*, together constitute 88 per cent. West of the Cascades, broad-leaved trees occur more plenti-

Fig. 6. Coniferous Forest along Columbia River, Oregon, consisting of red fi (*Pseudotsuga Douglasii* = *mucronata*) and incense cedar (*Libocedrus decurrens*). The undergrowth is *Acer macrophyllum*, *Mahonia (Berberis) aquifolium*, *Oxalis oregana*, and in clump the fern *Aspidium munitum*. Reproduced from photograph by RAU.

fully, forming on a numeric basis, about 6 per cent of the entire forest; anc while among the conifers, two species, *Pinus ponderosa* and *Pseudotsuga Douglasii* particularly predominate, there is also a wider range of ratios among the balance than is found on the eastern side of the range. The following species of coniferous trees form sylvan elements in the Cascade range anc adjacent territory of Oregon. Those marked by an asterisk * were not notec in the forests of Washington. Fig. 6 is illustrating the guild of *Pseudotsuga* and *Libocedrus*.

Pinus ponderosa Dougl.
» *Lambertiana Dougl.
» monticola Dougl.
» albicaulis Engelm.
» Murrayana Oreg. Com. (= P. contorta var. Murrayana Engelm.).
Abies concolor Lindl. & Gord., including transitional form to the northern Abies grandis.
» amabilis Forb.
» nobilis Lindl.
» subalpina Engelm. (= A. lasiocarpa Nutt.).
Pseudotsuga Douglasii Carr. (= P. taxifolia Poir. = P. mucronata Sudw.).
*Libocedrus decurrens Torr.
Cupressus (Chamaecyparis) nootkaensis Lamb.
Tsuga Mertensiana Bong. (= T. heterophylla Sarg.[1]).
» Pattoniana Jeffr. (= T. Mertensiana Sarg.).
Picea Engelmanni Engelm.
Taxus brevifolia Nutt.
Juniperus occidentalis Hook.

Among the various species of broad-leaved trees the following are abundant[2]) enough to become conspicuous factors of the forest in the Cascade range and adjacent territory. (* not noted in Washington.)

*Quercus californica Torr.
» Garryana Dougl.
Arbutus Menziesii Pursh.
Fraxinus oregona Nutt.
Acer macrophyllum Pursh.
Alnus oregona Nutt.
*Cercocarpus ledifolius Nutt.
*Cercocarpus betuloides Nutt.
*Castanopsis chrysophylla A. DC.
Pyrus (Malus) rivularis Dougl.
Populus tremuloides Michx.
» balsamifera L.
» trichocarpa Hook.
Sambucus glauca Nutt.

*Forests of Sierra Nevada Mountains.* The forests of the Sierra Nevada Mountains may be divided into three belts. The lower belt comprises a thinly stocked open forest mostly of oak at the lowest elevations, with a preponderance of scrubby pine at the higher elevations. Interspersed throughout this growth are strips of valley grassland and in the southwestern border low, broad hills of considerable extent frequently covered with chaparral. The middle belt is coniferous, pines predominate at the lower elevations, but in the higher sections cedar and fir are mingled with the pines in more or less equal numbers. The trees are usually of large dimensions such as the big tree *Sequoia gigantea*, *Pinus ponderosa*, *Pinus Lambertiana*. The upper forest belt is likewise coniferous in character, but the bulk of the timber is fir with mingled areas of inferior pines, juniper and hemlock. The lower elevations, including soil-covered, rocky benches and the mucky borders of subalpine meadows, contain the denser growths, while the bare, higher rocky elevations

1) Consult SUDWORTH, GEORGE B.: Forest Trees of the Pacific Slope. U. S. Forest Service 1908, the latest and best book on the subject.

2) LEIBERG, JOHN B.: Cascade Range and Ashland Forest Reserves and adjacent Regions. Twenty first Annual Report United States Geological Survey 1899—1900: 219.

have only a scattered growth of stunted trees. Those trees[1]) which are noted for the first time as not occurring in Washington are marked thus *, those not occurring in the Cascades thus †.

## Lower Belt.

*†Pinus Sabiniana Dougl.
*† » tuberculata Gord.
*†Salix lasiandra Benth.
*† » sessilifolia Nutt.
*†Populus Fremontii Wats.
*†Quercus lobata Nee.
*† » Douglasii Hook. & Arn.
*† » dumosa Nutt. var. revoluta Sarg.

*†Quercus Morehus Kell.
*† » Wislizeni A. DC.
*†Umbellularia californica Nutt.
*†Heteromeles arbutifolia Roem.
Acer macrophyllum Pursh.
*†Aesculus californica Nutt.
Rhamnus Purshiana DC.
Fraxinus oregona Nutt.
Sambucus glauca Nutt.

## Middle Belt.

*Pinus Lambertiana Dougl.
» ponderosa Laws.
*† » Jeffreyi Oreg. Com.
Pseudotsuga Douglasii Carr. (= P. taxifolia Poir.).
Abies concolor Lindl. & Gord.
*† » magnifica Muir.
*†Sequoia gigantea Decs. (= S. Washingtoniana Winslow, = S. Wellingtonia Seem.[2]).
*Libocedrus decurrens Torr.
*Taxus brevifolia Nutt.
*†Torreya (Tumion) californica Torr.
Populus trichocarpa Torr. & Gray.
*†Alnus rhombifolia Nutt.

*Castanopsis chrysophylla DC.
*Quercus chrysolepis Liebm.
* » Kelloggii Newberry.
*† » californica (Torr.) Coop.
* » (Pasania) densiflora Hook. & Arn.
* » dumosa Nutt.
*Cercocarpus parvifolius Nutt. var. brevifolia Gray.
*†Prunus demissa Walp.
*† » subcordata Benth.
Acer macrophyllum Pursh.
†Rhamnus Purshiana DC.
†Cornus Nuttallii Aud.
*†Arbutus Menziesii Pursh.

## Upper Belt.

Pinus monticola Dougl.
» albicaulis Engelm.
*† » Jeffreyi Oreg. Com.
» Murrayana Oreg. Com. (= P. contorta var. Murrayana Engelm.).

*†Pinus flexilis James.
*† » aristata Engelm.
Tsuga Pattoniana Jeffr. (= T. Mertensiana Sarg.).
Abies concolor Lindl. & Gord.
*† » magnifica Murr.

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1) SUDWORTH, GEORGE B.: Stanislaus and Lake Tahoe Forest Reserves. Twenty First Annual Report U. S. Geological Survey 1899—1900: 516; and MUIR, JOHN: The Mountains of California.

2) HARSHBERGER, JOHN W.: The Names of the Big Trees of California. Forest Leaves VII: 25, April 1898.

*Juniperus occidentalis Hook.
Populus tremuloides Michx.
*†Alnus tenuifolia Nutt.
*†Prunus emarginata Walp.
*†Acer glabrum Torr.

The continuation of the forest south of the Sierra Nevada is to be sought in the Sierra Madre Mountains in southern California. The distinguishing feature of the natural vegetation of southern California is the prevalence of shrubs [1]. Over three-fourths of the surface shrubs form the principal growth. Scattered in open order over desert, plain and valley as chaparral, it is seldom that shrubs give way to meadow and forest. At low altitudes the arboreal vegetation is mostly riparian. The streams are scantily fringed with alder, sycamore, cottonwood and a few species of willow. At an altitude of 4000 and 5000 feet the coniferous forest begins. The San Gabriel and San Bernardino mountains form together a portion of the Sierra Madre range. The general course of these mountains is from west to east. The general aspect of these mountains is extremely broken and rugged. The crest line of the main back bone of the range is moderately winding and from it steep declivities descend on the south flanks and north flanks, the latter being more abrupt than the former.

On San Jacinto and Grayback mountains is found an alpine flora which lingers on these summits along the banks of perpetual snow in the cool shaded canyons which descend the north side at altitudes between 10,000 and 10,800 feet. A single species *Ranunculus Eschscholtzii* has been found on both peaks, *Arenaria hirta* var. *verna* and *Antennaria alpina* have been collected on Grayback, while from San Jacinto, *Carex Preslii*, *Oxyria digyna* and the alpine forms of *Spraguea umbellata* and *Aquilegia truncata* [2].

The conspicuous vegetation of these mountains, which rise to above 10,000 feet, is however, of two types. 1. A brush or chaparral growth, more or less mixed with an open, thin or aggregated stand of trees, or wholly composed of shrubby plants except where broken by patches of naked rocks; 2. a forest growth, which, while generally heavy enough to deserve the designation of forest, is mostly of a thin stand, and composed of low, scraggy individuals.

The chaparral of the San Jacinto range (which has its northern termination at San Gorgonio Pass, a gap 4 to 5 miles wide separating the San Jacinto Mountains from the San Bernardino range), is similar to that mentioned above with the addition of *Adenostoma sparsifolium* (25 per cent), *Encelia farinosa*, *Lycium Andersonii*, *Pentstemon antirrhinoides*, *Pluchea sericea*, *Rhus ovata*, *Ribes sanguineum*, *Simondsia californica*.

The forest in the three mountain systems, San Gabriel, San Bernardino and San Jacinto, is given in the following list.

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1) Parish, S. B.: Distribution of Southern California Trees: Zoe. IV: 332.

2) Hall, Harvey M.: A botanical Survey of San Jacinto Mountain. University of California Publications, Botany 1: 1—140. June 7, 1902; Parish, S. B.: A Sketch of the Flora of southern California. Botanical Gazette XXXVI: 214.

| | San Gabriel | San Bernardino | San Jacinto |
|---|---|---|---|
| **Coniferous.** | | | |
| Abies concolor Lindl. & Gord. | + | + | + |
| Juniperus californica Carr. | + | + | + |
| » occidentalis Hook. | — | + | — |
| Libocedrus decurrens Torr. | + | + | + |
| Pinus attenuata Lemmon (= P. tuberculata Gord.) | + | + | — |
| » Coulteri Don. | + | + | + |
| » flexilis James | + | + | + |
| » Lambertiana Dougl. | + | + | + |
| » monophylla Torr. & Frem. | + | + | + |
| » Murrayana (= P. contorta Murrayana Engelm.) | + | + | + |
| » ponderosa Dougl. | + | + | + |
| » quadrifolia (= P. Parryana Engelm.) | — | — | + |
| Pseudotsuga macrocarpa Mayr. | + | + | + |
| **Evergreen (non coniferous).** | | | |
| Cercocarpus betulaefolius Nutt. | + | — | — |
| » ledifolius Nutt. | + | + | + |
| Quercus chrysolepis Liebm. | + | + | + |
| » Wislizeni A. DC. | + | + | + |
| Rhus ovata Wats. | — | — | + |
| Yucca arborescens Trel. (= Y. brevifolia Engelm.). | + | + | + |
| **Deciduous-leaved.** | | | |
| Alnus rhombifolia Nutt. | + | + | + |
| Fraxinus velutinus | — | + | + |
| Fremontodendron (Fremontia) californicum Torr. | + | + | + |
| Chilopsis linearis DC. (= C. saligna Don.) | — | — | + |
| Juglans rupestris Engelm. | + | + | + |
| Platanus racemosa Nutt. | + | + | + |
| » Fremonti Wats. | — | — | + |
| Populus trichocarpa Hook. | + | + | + |
| Prosopis juliflora DC. | — | — | + |
| Quercus californica Torr. | + | + | + |
| » Morehus Kell. | — | — | + |
| Salix lasiandra Benth. | + | + | + |

The forest trees in these mountains below the 3000 foot contour are *Alnus rhombifolia*, *Platanus racemosa*, *Populus trichocarpa*, *Quercus chrysolepis*, *Salix lasiandra*. The coniferous trees begin to grow at altitudes of 3000 feet (915 m). The first to appear are *Pinus Coulteri* and *Pseudotsuga macro-*

*carpa.* At 4800 feet (1460 m) elevation, the trees begin to form a forest with the following species as the chief components: *Abies concolor*, *Libocedrus decurrens*, *Pinus Coulteri*, *Pinus ponderosa*, *Pseudotsuga macrocarpa*, *Quercus californica* and *Quercus chrysolepis.* At altitudes of 5400 feet (1650 m) *Pinus Lambertiana* becomes an element in the forest. The forest at the 7000 foot (2130 m) contour line consists of *Abies concolor*, *Cercocarpus ledifolius*, *Juniperus californica* and *J. occidentalis*, *Libocedrus decurrens*, *Pinus Lambertiana*, *Pinus monophylla*, *Pinus Murrayana* and *Quercus chrysolepis.* This oak ceases with all other species of oaks at 8000 feet (2440 m). From 9500 to 11,700 feet (2900—3570 m), which is the highest elevation in the San Bernardino range, the forest consists almost wholly of *Pinus flexilis* and *Pinus Murrayana* [1]).

The mountain flora as the above lists show is essentially a Sierra Nevadan flora projected southward. *Aesculus californica*, *Quercus Douglasii*, *Q. Wislizeni* var. *frutescens*, *Pinus sabiniana*, *Myrica californica*, *Arbutus Menziesii* barely enter southern California from the San Joaquin district and hence are forced into a narrow belt between the desert and the mountains over which they have been unable to pass to a region better adapted to them.

The following plants form a conspicuous desert element of the flora: Fremontodendron (Fremontia) californicum*, Dalea spinosa, Olneya tesota, Prosopis juliflora*, Prosopis pubescens*, Acacia Greggii*, Chilopsis saligna (= C. linearis), Yucca baccata*, Yucca brevifolia, Pinus monophylla, Juniperus californica. Those marked with an asterisk pass to a greater or less extent into the intramontane area which is essentially occupied by a Californian flora many plants of which were originally derived from the great Sonoran life area. Among the prominent intramontane species are: Rhamnus californica, R. californica var. tomentella, Acer macrophyllum, Negundo californicum, (= Acer negundo var. californicum), Prunus ilicifolia, Prunus demissa, Cercocarpus parvifolius, Heteromeles arbutifolia, Sambucus glauca, Umbellularia californica, Juglans rupestris, Quercus chrysolepis, Quercus agrifolia, Quercus lobata, Alnus rhombifolia, Populus Fremonti var. Wislizeni, Salix laevigata, Salix lasiolepis, Salix lasiandra var. lancifolia, Platanus racemosa.

The lower limit of the Sierra Nevada element of the flora on the mountains of southern California coincides with that of *Pinus ponderosa.* This ranges according to exposure from 5000 (1524 m) to 7000 feet (2133 m). The genera given below in the first column are represented by species which belong exclusively to the flora of the Sierra Nevada, while the boreal genera are mentioned which have a more or less wide distribution throughout the whole boreal zone of the Pacific mountain ranges.

## Genera found only in the Nevadan Territory.

Exclusively Nevadan [2]).

| | | |
|---|---|---|
| Libocedrus. | Iris. | *Lewisia.* |
| *Danthonia.* | Corallorhiza. | *Cycladenia.* |
| *Hemicarpha.* | Castanopsis. | *Boschniakia.* |
| Veratrum. | Spraguea. | Heuchera. |

1) The elevations above are not absolute, but vary with the slope and exposure.

2) Genera abundant and widely distributed in spread letters: those local and rare in *italics.*

| | | |
|---|---|---|
| *Philadelphus.* | *Pyrola.* | Kelloggia. |
| *Heterogaura.* | *Chimaphila.* | Hemizonella. |
| Sphaenosciadium (= Selinum in part). | Sarcodes. | Hulsea. |
| Heracleum. | Rhododendron. | *Raillardella.* |
| | *Bryanthus.* | |

Boreal.

| | | |
|---|---|---|
| Athyrium. | Luzula. | Myriophyllum. |
| *Woodsia.* | Smilacina. | Gentiana. |
| Cystopteris. | Actaea. | *Polemonium.* |
| *Cryptogramma.* | Barbarea. | Lappula (= Echinospermum). |
| Abies. | Pterospora. | Taraxacum. |
| Alopecurus. | Geum. | Crepis. |
| Glyceria. | Hypericum. | Hymenopappus. |
| Puccinellia. | Circaea. | Arnica. |
| *Trisetum.* | Hippuris. | |

From a consideration of this table, it is evident that the flora of these southern mountains coincides with that of the general Sierra Nevada.

*Southern Extension of Californian Plants.* A number of trees of shrubs of California proper find their southern limital extension in the peninsula of Baja California. Such are: *Pinus Jeffreyi*, *Pinus Lambertiana*, *Libocedrus decurrens*, *Rhamnus californica*, *Juniperus californica*, *Abies concolor*, *Sambucus glauca* and *Symphoricarpus mollis* [1]). This peninsula in conclusion contributed *Pinus Parryana* and *Washingtonia filifera* to southern California.

The Coast range is the general name for the great mountain system which stretches along the Pacific coast from Puget Sound to southern California. It is not a continuous range, but a broken mass of parallel, ridges from forty to seventy miles wide, with many other chains transverse to the general trend of the range. Streams cut through the mountains here and there and through their valleys flow fogs to modify the local climates. In the Coast range, there is no warm belt, but isolated warm spots, which depend on altitude, prevailing wind, fog and exposure. The rainfall is even more capricious than the temperature. The eastern slopes are dry and the western in general wet. Under such conditions, the flora of the Coast range cannot be other than interesting, for plants are much localized and frequently found there out of their usual range. The full explanation of these peculiarities will be given in a short space.

Nowhere in the range is there greater variety than in the area comprised within Mendocino and Lake counties, California. A narrow table-land next the ocean together with sand dunes and salt lagoons are found. *Pinus muricata* originally covered the table-lands. A few miles back high terraces lie between the deepcut river channels and up the river cañons on the ocean

1) BRANDEGEE, T. S.: Southern Extension of California Plants. Zoe IV: 201. Oct. 1893.

side according to the observations of the writer the redwood forest begins and stretches to the top, of the range which, at twenty miles from the sea, forms a barrier 2000 feet high, between the coast and the interior.

*Southern Coast Range Flora.* Three mountains in the middle coast ranges of western central California are of interest in depicting briefly the characteristic mountainous flora of these parts of North America, Mount St. Helena (4343 feet, 1324 m), Mount Diablo (3849 feet, 1171 m), Mount Hamilton (4209 feet, 1282 m) may be contrasted for this purpose[1]). On account of its volcanic character (entire summit above 2300 feet covered with ash) and the scarcity of water, the number of species of plants found on Mount St. Helena is very small. Meager as the vegetation is in species, it would be even less were the mountain located in the inner instead of the middle coast ranges. Its situation is in a region of great annual rainfall, and the fogs hang about the mountain at intervals during the rainless season for a portion of the day for a period of several days to a week or more. The conditions on Mount Diablo are similar, distant sixty-seven miles. The vegetation of the mountains is, therefore, more rank than on Mount Hamilton which is not so favorably situated with regard to moisture. Notwithstanding the arid character of the summit of Mt. St. Helena, it possesses a few species characteristic of the humid coast region, or of the high Sierras and other elevated mountain ranges, such as, *Pseudotsuga Douglasii*, *Cornus Nuttallii*. Three species of *Ceanothus*, *C. velutinus* var. *laevigatus*, *C. prostratus* var. *divergens*, and *C. foliosus*, all found on Mt. St. Helena are not found in the inner north-coast range, nor yet on Mount Diablo. The vegetation of the summit is distinguished by the prevalence of shrubs of a limited number of species which completely mantle the sides of the mountain above 2300 to 2500 feet. *Arctostaphylos Manzanita* is very abundant, particularly at the highest elevation, and numerically outranks all other species. *Garrya Fremonti*, *Xylothermia montana*, *Rhamnus californica* and *Ceanothus foliosus* are common. *Castanopsis chrysophylla* also occurs and *Quercus chrysolepis* and *Q. Wislizenii* in scattered individuals. There is a conspicuous lack of herbaceous species above 3000 feet, only such as *Hypericum concinnum*, *Pedicularis densiflora*, *Monardella odoratissima* and *Zygadenus Fremontii* being found.

The Chemisal, or Chemise brush, covers slope after slope, hill after hill, and mile after mile with a low dense growth of a uniform blue green due to the shrub *Adenostoma fasciculatum*. A fern, *Pellaea ornithopus*, grows in dense tufts on the hot slopes where in the chemisal some rocks have been broken into fine debris.

The barrier range mentioned above between the coast ranges and the interior is diversified by masses of *Pseudotsuga* and species of *Quercus*, thickets

1) JEPSON, WILLIS L.: Vegetation of the Summit of Mt. St. Helena. Erythea VII: 105 Oct. 31, 1899. GREENE, E. L.: The Vegetation of Mt. Diablo. Erythea I: 166. GREENE, E. L.: The Vegetation of the Summit of Mt. Hamilton. Erythea I: 80. These mountains are given in the order of their north-south position.

of chemisal, open grassy slopes, mountain meadows with small patches of redwood in canyons or on cool slopes. Snow Mountain east of the San Hedrin Mountain has its upper slopes and dry valleys covered with forests of *Libocedrus*, *Pseudotsuga*, *Pinus Jeffreyi* surrounded by thickets of *Prunus emarginatus*, *Ceanothus cordulatus* and as herbs *Gilia aggregata*, *Spraguea umbellata*, *Eriogonum umbellatum* with *E. ovalifolium* and *E. Lobbii*.

The plants of the Sierra Nevada Mountains found growing in the Coast ranges differ somewhat, in most cases, a difference easily explained by their isolation and difference of situation [1]).

A comparison of the species of the genus *Ribes* [2]) richly represented in California brings out the fact that the separation of the two mountain systems by the great valley is sufficient to produce forms different enough to entitle them to rank as distinct species.

| Coast Region. | Sierra Nevada. |
|---|---|
| a) Currants. | |
| Ribes bracteosum Dougl. | Ribes viburnifolium A. Gray. |
| » sanguineum Pursh. | » laxiflorum Pursh. |
| » scuphami Eastw. | » viscosissimum Pursh. |
| » glutinosum Benth. | » nevadense Kellogg. |
| » malvaceum Smith. | » variegatum S. Wats. |
| » viridiflorum Abrams. | » adscendens Eastw. |
| » indecorum Eastw. | » glaucescens Eastw. |
| » hirtellianum Eastw. | |
| b) Gooseberries. | |
| Ribes Menziesii Pursh. | Ribes lacustre Poir. |
| » hystrix Eastw. | » divaricatum Dougl. |
| » californicum H. & A. | » quercetorum Greene. |
| » occidentalis H. & A. | » speciosum Pursh. |
| » oligacanthum Eastw. | » mariposanum Congdon. |
| » victoris Greene. | » amictum Greene. |
| » sericeum Eastw. | » Wilsonianum Greene. |
| » subvestitum H. & A. | » aridum Greene. |
| » Lobbii A. Gray. | » saxosum Hook. |
| » Marshallii Greene. | » lasianthum Greene. |
| » cruentum Greene. | » Congdoni Heller. |
| » hesperium McClatchie. | » velutinum Greene. |
| » amarum McClatchie. | |

Only two species *cereum* and *lentum* seem to be common to both the coast region and the Sierra Nevada.

Although possessing many species in common the flora of the Coast ranges is decidedly different from that of the Sierra Nevadas. JEPSON [3]) regards the flora of these Coast ranges as decidedly endemic and much the oldest and most unique, as the following lists by Miss ALICE EASTMAN will indicate.

1) BRANDEGEE, KATHARINE: Sierra Nevada Plants in the Coast Range. Zoe IV: 168.

2) HELLER, A. A.: The Genus Ribes in California. Muhlenbergia I, No. 5: 63.

3) In a letter to the writer dated December 1, 1903.

1. Genera found in the Coast Mountains and not in the Sierra Nevada. (Those marked with * asterisks are peculiar to the Coast Mountains.)

*Achlys, *Vancouveria, *Romneya, Papaver, Meconopsis, *Stanfordia, Caulanthus, Stanleya, *Isomeris, Frankenia, Mesembryanthemum, *Calyptridium, Abutilon, *Cneoridium, Euonymus, *Adolphia, *Pickeringia (= Xylothermia), Amorpha, Acaena, *Tiarella, *Whipplea, *Tolmiaea (= Leptaxis), Viburnum, Linnaea, *Pentachaeta, *Heterotheca, Pluchea, Encelia, Viguiera, Jaumea, Venegasia, *Burrielia, *Actinolepis (= Eriophyllum in part), *Lasthenia (= Baeria in part), *Amblyopappus, *Blennosperma, Petasites, *Rafinesquia (= Nemoseris), Gaultheria, Menziesia, Monotropa, *Pholisma, Armeria, Microcala, *Loesilia, Romanzoffia, Petunia, *Micromeria, Synthyris, Calamintha (= Clinopodium), Mirabilis, Allionia, Boerhavia, *Nemacaulis, Lastarriaea, Aphanisma, Salicornia, Spirostachys, Dirca, Hesperocnide, Parietaria, *Simmondsia, Croton, Acalypha, Stillingia, Aristolochia, Cupressus, Calypso, Agave, *Brevoortia, *Hesperocallis, *Scoliopus, Lysichiton.

2. Genera found in the Sierra Nevada not found in the Coast Mountains. (Those marked with an * asterisk are peculiar to the Pacific coast Flora.)

Aconitum, Smelowskia, Parrya, Staphylea, *Chamaebatia, Purshia, Sibbaldia, *Carpenteria, Valeriana, Eupatorium, Sericocarpus, Rudbeckia, *Whitneya, *Hulsea, *Laurentia, Cassiope, Bryanthus, Kalmia, Sarcodes, Primula, Swertia, Styrax, Frasera, Draperia, *Hesperochiron, *Nama, Chamaesaracha, Mertensia.

An examination of the first list will show that the Coast ranges lack those northern genera which may be called boreal-alpine, while the second list of genera peculiar to the Sierra Nevada Mountains includes such boreal-alpine genera as Sibbaldia, Cassiope, Bryanthus.

Outside floral elements enter and mix with the true endemic coast flora. The northern element from Oregon and Washington is practically coextensive with the redwood belt and extends, as far southward, as Marin County, although there are two considerable islands south of San Francisco Bay, one in the Santa Cruz Mountains and a smaller one in the Santa Lucia Mountains. All of the typic redwood, or undergrowth plants are characteristically northern.

We have here a mass invasion of a northern species-guild ("Artengenossenschaften") into a redwood forest as an undergrowth, the redwood forest with its species-guild antedating by many periods of time the occupancy of the territory. The undergrowth is an alien association thoroughly naturalized in its new quarters. The species characteristic of low altitudes are later invaders and many of them have entered from the south. The Sonoran element overlaps the southern portion of the Coast Range between San Francisco Bay and Tehachapi Pass. In southern California, the Sonoran element reigns supreme. Along the eastern edge of the Coast ranges where they abut on the great central valley of California, we find the influence of the coast range flora extending eastward to the Sacramento and San Joaquin rivers. Similarly, the flora of the plains is felt on the eastern slopes of the mountains.

The district between the San Bernardino Range and the sea may be designated as the *Cismontane District.* Two fairly distinct sub-districts (territories) are noticeable viz., the coastal territory and the interior territory which includes the San Fernando, San Bernardino and San Jacinto valleys. Where the wide Los Angeles valley opens out to the sea the two territories unite, and some of the most characteristic coastal species are carried inland to the base of the San Gabriel Mountains.

Species restricted respectively to the

| Interior Subterritory. | Coastal Subterritory[1]. |
|---|---|
| Adiantum Capillus-Veneris L. | Adiantum emarginatum Hook. |
| Andropogon macrourus Michx. | Andropogon saccharoides Sw. |
| Antirrhinum glandulosum Lindl. | Antirrhinum Nevinianum A. Gray. |
| Aplopappus linearifolius DC. | Aplopappus ericoides H. & A. |
| Artemisia Parishii A. Gray. | Artemisia Palmeri Gray. |
| Boykinia rotundifolia Parry. | Boykinia occidentalis T. & G. |
| Calochortus Plummerae Greene. | Calochortus Weedii Wood. |
| » splendens Dougl. | » Dunnii. |
| Carex Barbarae Dewey. | Carex spissa Bailey. |
| Chorizanthe fernandina Wats. | Chorizanthe laciniata Torr. |
| » Parryi Wats. | » fimbriata Nutt. |
| Euphorbia ocellata Dur. & Hilg. | Euphorbia misera Benth. |
| Gilia californica Benth. | Gilia floribunda Gray. |
| Helianthus Parishii A. Gray. | Helianthus Oliveri A. Gray. |
| Hemizonia (Deinandra) Wrightii A. Gray. | Hemizonia virgata A. Gray. |
| Lathyrus laetiflorus Greene. | Lathyrus splendens Kell. (= L. vestitus Nutt.). |
| Monardella Pringlei A. Gray. | Monardella hypoleuca A. Gray. |
| Opuntia Bernardina Engelm. | Opuntia prolifera Engelm. |
| Phacelia Davidsonii A. Gray var. | Phacelia Douglasii Torr. |
| Ribes glutinosum Benth. (= R. sanguineum Pursh. var. glutinosum). | Ribes speciosum Pursh. |
| Zauschneria californica Presl. | Zauschneria californica Presl. var. microphylla A. Gray. |

Several desert plants pass into the cismontane district viz. *Prosopis juliflora*, *Encelia farinosa* and *californica*, etc., while hardly a distinctively cismontane species enters the confines of the desert.

*Coast Islands of California.* The flora of the coast islands of California now demands attention as its history is intimately connected with the development of the flora on the mainland. These islands fall geographically into two groups, a northern and a southern. To the former belong San Miguel, Santa Rosa, Santa Cruz and Anacapa. The islands of the southern group are San Clemente, Santa Catalina, Santa Barbara and San Nicolas with Begg's Rock, which stands in relation to San Nicolas. A minimum elevation of about 175 feet would add to the groups as islands what are now three submarine elevations known as Cortes, Tanner and Osborn banks. One group of these islands has simple topography, with comparatively gentle slopes and moderate, or slight dissection; the other has rugged, sharply incised and serrated forms. Classifying the islands on the basis already given, we have belonging to the

1) PARISH, S. B.: l. c. 262.

group with simple topography San Clemente, with extremely young topography in generally hard rocks; San Nicolas, with young topography in soft rocks; San Pedro Hill with modified mature topography, now presenting, on the whole, the forms of adolescence, developed in moderately soft rocks; San Miguel, with modified mature topography, though belonging, according to its general character, with the more rugged islands. To the group with rugged topographic forms belong Santa Catalina, Santa Cruz and the larger part of Santa Rosa. It is probable, that all of the islands originated through crustal deformation, for the most part, as tilted blocks[1]).

The botany of the Californian islands is of interest on account of the variations from mainland forms, largely due to isolation and the effect of insular climate. The list of species found on the islands contains about 512 species. Twenty six species of the list have not yet been found on the mainland, though all but three are near relatives of coast forms and twelve of these twenty six plants have been found on the islands off the coast of Lower California, leaving only fourteen species which are probably peculiar to the islands.

There are a number of species and genera peculiar to the islands and these peculiarities in part with other characteristics may be ascribed to the survival of an old flora on the islands, while that of the mainland has been more or less modified by the intrusion of new forms from other regions since the separation of the islands from the continent proper. *Lyonothamnus*, consisting of two very distinct species, has no very near relative in any other part of the world. *Crossosoma* another genus of shrubs has one species indigenous to several islands with none on the immediately neighboring mainland, though a second small and insignificant member of the genus occurs on the verge of the interior deserts. Four species of *Lavatera* are scattered up and down the archipelago, while not a single species is indigenous to the American continents, all the generic allies being of the Mediterranean region, with the exception of three or four, which are confined to remote and truly oceanic islands. Another negative point of divergence between the insular and mainland floras is the almost or total absence from the islands of such prevalent mainland genera as Ribes, Lupinus, Astragalus, Potentilla, Horkelia, etc. Equally remarkable is the fact, that certain trees, shrubs and herbaceous plants long known as extremely rare, or quite local, on the mainland, such as *Pinus Torreyana*, *Malacothrix incana* and *Leptosyne gigantea*, occur on the islands in the most luxuriant abundance. Such plants also as *Potentilla anserina*, *Cressa cretica*, *Jaumea carnosa* and two species of *Salicornia* confined to salt marshes occur on San Miguel Island and not on the others, because none of the others have as much as a square rod of that kind of ground. *Aplopappus ericoides*, *Troximon grandiflorum*, *Sidalcea malvaeflora*, *Gilia micrantha*, *Plan-*

1) Smith, W. S. Tangier: A topographic Study of the Islands of southern California. Bulletin Department Geology University of California II: 179.

*tago hirtella* and *Scirpus riparius* are plants of the northern coasts mainly and their rareness on San Miguel indicates that they formed no part of the old flora of the island, but have appeared there in recent times, owing to the course of winds and currents. In the subjoined list [1]) species endemic to Santa Catalina, San Clemente are in italics; species closely connected with continental ones, perhaps mere varieties of them, are designated by an asterisk.

| | |
|---|---|
| *Astragalus Nevinii* A. Gray. | *Hemizonia Clementina* T. S. Brandegee. |
| *Ceanothus arboreus Greene. | Lavatera assurgentiflora Kell. |
| **Cercocarpus Traskae* East. | *Phacelia Lyoni* A. Gray. |
| *Crossosoma californica Nutt. | Lyonothamnus floribundus A. Gray. |
| *Eriogonum giganteum Wats. | Malacothrix foliosa A. Gray. |
| *Eriophyllum Nevinii* A. Gray. | » insularis Greene. |
| Galium catalinense A. Gray. | *Plantago dura* Morris. |
| Gilia Nevinii A. Gray. | Quercus tomentella Engelm. |

The fact that the majority of insular species are identic with those of the mainland and that only a few genera and species are endemic to the islands argues for a former land connection. The flora of the islands may be looked upon as the survivors of a coast flora, which was widely distributed along the shores of California before the period of subsidence, when these islands, which are approximately parallel with the present coast line, were isolated by the general subsidence of land beneath the sea. When the subsidence occurred, the old California coast flora was preserved almost unchanged on the islands and, therefore, enables us to determine the character of the original endemic coast flora, while on the mainland after the separation of the islands the species were subjected to the influence of new elements which migrated into the Californian area from the north, south and east after the close of the glacial period. Excluding weeds and other species of wide distribution, we have in the above list an enumeration of species which represent collectively the ancient coastwise flora of California. According to this view all species of the islands did once inhabit the mainland, but the existing differences are due to the destruction of species, or their transformation in their struggles with invaders. There are quite a number of rare and peculiar forms such as *Pinus Torreyana* found struggling for existence on the mainland. These are probably remnants of Pliocene indigenes still undestroyed, but ready to perish. The distribution of the genus *Lavatera* also is explained by reference to past conditions. Several species of *Lavatera* perhaps existed all over the coast region of California which is represented by the present chain of islands. They have all been destroyed by change of environment except those isolated on the islands and thus saved from the effects of invasion and aridity [2]).

1) PARISH, S. B.: A Sketch of the Flora of southern California. Botanical Gazette XXXVI: 264, where a complete bibliograpby of papers on the island floras is given.

2) LE CONTE, JOSEPH: The Flora of the Coast Islands of California in Relation to recent Changes of physical Geography. American Geologist 1: 76—81. 1888.

That such oscillations have occurred is proved by the record which geologists have determined. During the post-Miocene it is probable that all the islands then differentiated were mountainous masses belonging to the mainland. Judging from their topography, and the apparent genetic relationships of those of the northern group, the forms then existing probably included all the present islands, except San Nieolas and San Clemente. The latter appear not to have been elevated until, the close of the post-Miocene erosion period, or early in the Pliocene depression. The post-Miocene elevation of the coast was followed by the Pliocene depression during which the sea stood for a long time some 1500 feet above its present level and the coast had the aspect of an archipelago. During this depression at first Santa Catalina, San Clemente, San Pedro Hill, Santa Cruz and Santa Rosa all existed as islands, or as in the case of Santa Cruz and Santa Catalina, as two or more small islands. Then as now, Santa Cruz was probably the highest, if not the largest of the existing islands. This depression was followed by a post-Pliocene elevation. This elevation was perhaps sufficient to connect the northern islands with the mainland, none of the southern islands have had such connection since the post-Miocene period of erosion. The most recent movement of the coast, as indicated by drowned valleys and submarine features, is a comparatively slight depression. Paleontologic evidence is not wanting for in the pliocene rocks on the peninsula of San Francisco are found cones of *Pinus insignis* (*P. radiata*, Monterey pine), a tree which at the present time grows only at Monterey [1]).

With this radical transformation in the physiography of the coast, there have doubtless been very important changes in the climate, and in this fact is to be found, the explanation of certain remarkable and anomalous features in the distribution of the plants of the coast. As a consequence of the general uplift of the coast and southern California, the physiography of the country has been radically changed in the most recent geologic times. The area below the sea or influenced by delta deposits was tenanted in the great central valley and along the slopes of the elevated mountains of southern California with plants derived from the south. These at the present day form the desert and chaparral vegetation of the summits of the lower hills which were once beneath water and on the mountain flanks, while the higher mountain summits which existed as islands during the last submergence are clothed with a forest vegetation which during the Pliocene depression existed nearly at sea-level. With increasing aridity the lower limits of the mountain forests was determined by available moisture. A tentative arrangement of the vegetation elements in southern California according to their age is herewith given:

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1) FAIRBANKS, W. H.: The Age of the California coast Ranges. American Geologist XVIII, 1896: 271. LAWSON, ANDREW C.: The post-Pliocene Diastrophism of the Coast of southern California. Bulletin Department Geology University of California I: 115—160. RANSOME, F. LESLIE: The Great Valley of California do. Univ. of California I: 371—428. SMITH, W. S. TANGIER: *A topographic Study of the Islands of southern California do.* Univ. of California II: 179—230.

1. Original coastwise vegetation (now on islands and mainland).
2. Mountain forests.
3. Chaparral.
4. Boreal-alpine plants on mountain summits.
5. Desert and Great Valley vegetation.

With increased elevation and the exposure of fresh areas to invasion desert species moved into the arid regions and grasses and other plants into moister situations to form the grass-land and tule formations of the great San Joaquin valley and other smaller valleys, that owe their soils to a delta formation.

*Great Valley of California.* The Great valley of California, which lies between the Sierra Nevada Mountains on the east and the Coast ranges on the west, is an alluvial plain with little departure from a monotonous level surface. It includes three basins of drainage called respectively Sacramento valley (northern), San Joaquin valley (southern) and the depression of Tulare Lake. From the orogenic disturbance at the close of the Miocene, when the coast ranges appeared as a connected mountain chain dates the history of the Great valley. During the Neocene, the Great valley was occupied by a gulf, connecting with the ocean by one or more sounds across the Coast ranges. During Pleistocene times, the Great valley was finally cut off from the sea. The elevation of mountains closed in the valley which became a well defined area of sedimentation, or deposit. With the surface of the ground only 46 feet above sea-level, the occurrence of logs of wood at 340 feet, recent shells up to 600 feet can only be thus accounted for by subsidence and deposition, when sediments 2000 feet in thickness were formed. The Great valley is, therefore, an example of a well defined area of progressive subsidence associated with heavy accumulations of sediments.

A flora older than that of the plain flora of the valley consists of the formations which are found in the tule swamps, or marshy areas which border the rivers for a considerable distance on either bank. The Sacramento River is bounded by brackish marshes for 150 miles from its mouth which stretch away from the river ten to fifteen miles on either hand. These marshes are commonly referred to as tule lands. Along the new and old river channels the deposition of sediments has built up natural levees with brackish water back of them where waving masses of tule (*Scirpus lacustris* var. *occidentalis*) occur.

The following trees and shrubs fringe the water ways [1].

| | |
|---|---|
| Salix nigra Marsh. | Platanus racemosa Nutt. |
| » lasiandra Benth. | Populus Fremontii Wats. |
| » longifolia Muhl. | Cephalanthus occidentalis L. |
| » sessilifolia Nutt. | Fraxinus oregana Nutt. |

1) Jepson, Willis L.: The riparian Botany of the lower Sacramento. Erythea I, 1893: 238. Brandegee, K.: Flora of Bouldin Island. Zoe IV: 212.

Juglans californica Wats.
Alnus rhombifolia Nutt.
Vitis californica Benth.
Rosa californica C. & S.
Rubus vitifolius C. & S.
Acer californicum Greene.
Rhus diversiloba T. & G.
Quercus Wislizeni DC.
Cornus pubescens (= C. occidentalis T. & G.) Nutt.

On small islands in the swamps, the indigenous growth is rank: *Hypericum mutilum*, *Eclipta alba*, *Bidens frondosa*, *Lippia lanceolata*, *Amaranthus hypochondriacus*, *Lippia cuneifolia*. An evident relationship exists between this flora and the riparian one of the lower Mississippi River and its tributaries. The plants to be mentioned in this connection are: *Isnardia palustris*, *Pluchea camphorata*, *Eclipta alba*, *Lippia lanceolata*, *Cyperus diandrus* var. *castaneus*, *C. erythrorhizos*, *C. stenolepis*. Fully fifty per cent of plants in the following list are common, although not peculiar to this region and the Mississippi.

Lathyrus Jepsoni Greene.
Psoralea macrostachya DC.
Glycyrrhiza glutinosa Nutt.
Euphorbia serpyllifolia Pers.
Hibiscus californicus Kell.
Hypericum mutilum L.
Polygonum Muhlenbergii Wats.
» Hartwrightii Gray.
» acre H. B. K.
» nodosum Pers.
Atriplex coronata Wats.
» spicata Wats.
» hastata L. v. oppositifolia Moq.
Epilobium paniculatum Nutt.
» holosericeum Trelease.
» californicum Haussk.
Boisduvalia densiflora Lindl. & Wats.
Isnardia palustris L.
Jussiaea diffusa Forsk. var. californica [Wats.
Ammannia coccinea Rottb.
Nasturtium (Roripa) dictyotum Greene.
Hydrocotyle prolifera Kell.
Sium heterophyllum Greene.
Solidago californica Nutt.
» elongata Nutt.
Euthamia occidentalis Nutt.
Aster exilis Ell.
» Douglasii Lindl.
Gnaphalium palustre Nutt.
Baccharis Douglasii DC.
Pluchea camphorata DC.
Eclipta alba Haussk.
Helianthus californicus DC.
Bidens frondosa L.
» laevis (L.) B. S. P.
Ambrosia psilostachya DC.
Artemisia vulgaris L. v. californica Bess.
Apocynum cannabinum DC.
Heliotropium curassavicum L.
Convolvulus sepium L.
Solanum Douglasii Dunb.
Stachys albens Gray.
» ajugoides Benth.
Pogogyne Douglasii DC.
Lycopus sinuatus Ell.
Verbena hastata L.
Lippia cuneifolia Steud.
» lanceolata Michx.
Urtica holosericea Nutt.
Sagittaria variabilis Engelm.
Alisma plantago-aquatica L.
Scirpus lacustris L.
» tatula.
Cyperus diandrus, var. castaneus Torr.
» erythrorhizos Muhl.
» stenolepis Torr.

The herbaceous plants of the Californian plain are chiefly annual, and the rapidity with which they attain their full size, perfect their seed and pass

away is remarkable. The wide plain is covered with plants belonging to the following genera: *Lupinus*, *Trifolium*, *Calandrinia*, *Platystemon*, *Eschscholtzia* (notably the orange-flowerd *E. crocea*), *Baeria*, *Gilia*, *Nemophila*, *Allocarya*, *Bahia*, *Madia*, *Madaria*, *Burrielia*, *Chrysopsis*, *Pentstemon*, *Coreothrogyne*, *Phacelia*, *Grindelia*, growing in close association and blending with the purples of *Clarkia*, *Orthocarpus*, *Oenothera*. The shallow streams and pools are edge with species of *Eunanus* and *Bolelia*. The tide of plant life reaches its maximum from April fifth to twentieth. In one, two or three weeks more, the brilliant colors have faded and the vernal aspect is succeeded by the dullness and aridity of summer. June, July, August and September is the season of rest and sleep, of dry heat, followed in October by a second outburst of bloom at the very driest time of the year. *Hemizonia virgata* appears and carpets the ground remaining in flower until November, uniting with two or three species of *Eriogonum*, which continue the floral chain through December until the spring flowers appear again.

In contrast to the Spring growth on the plains, the height of the season for the herbaceous growth of the river region is in September and October, when the landscape is as fresh and green as the landscape in April on the plains. *Verbena hastata*, *Euthamia occidentalis*, *Aster Douglasii*, *Stachys albens*, and *Gnaphalium californicum* are mere instances of decided color. Annuals are commonly four to five feet tall.

Clearly the flora of the tule swamps is sharply demarcated from and older than the plains flora, for there is geologic and physiographic evidence that in addition to a subsidence of great recency to the extent of at least 378 feet at the mouth of the Sacramento River, flooding the lower portion of the valley, giving us the magnificent harbor at San Francisco [1]), there were series of preceding subsidences, followed by the deposition of sediments [2]).

During this entire period of subsidence and sedimentation, the edaphic conditions were such in the brackish marsh areas along the coast line of the landlocked sea, now represented by the Great valley as to permit the growth of a marsh flora which still persists in similar situations at the present day. Then too, the present marsh flora, closely related to that in eastern marshes must have entered the region, when the divergences between the eastern and western floras were still less pronounced and before sedimentation permitted the later and present plains flora to occupy the now dry central valley.

There are also certain plants that are confined to the immediate shores of the ocean in southern California [3]), either on the sand of the beach, or in the tidal marshes or meadows. These are exhibited in the subjoined table.

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1) LAWSON, ANDREW C.: The Geomorphogeny of the Coast of northern California. Bulletin Department Geology University of California I: 241—272.

2) See ante page 277.

3) PARISH, S. B.: A Sketch of the Flora of southern California. Botanical Gazette XXXVI: 260. 1903.

| Arenicolous Species. | Halophilous Species. |
| --- | --- |
| Abronia maritima Nutt. | Astragalus pycnostachys A. Gray. |
| » umbellata Lam. | Atriplex hastata L. |
| Amblyopappus pusillus H. & A. | Batis maritima L. |
| Aphanisma blitoides Nutt. | Jaumea carnosa A. Gray. |
| Atriplex leucophylla Dietr. | Juncus acutus L. var. |
| » microcarpa Dietr. | Monanthochloe littoralis Engelm. |
| Calandrinia maritima Nutt. | Salicornia ambigua Michx. |
| Convolvulus soldanella L. | » herbacea L. |
| Franseria (Gaertneria) bipinnatifida Nutt. | » mucronata Bigel. (= S. Bigelovii Torr.). |
| Mesembryanthemum aequilaterale Haw. | Scirpus Tatora Kunth (= S. riparius J. & C. Presl.). |
| » crystallinum L. | Spartina glabra Muhl. |
| » nodiflorum Haw. | Statice limonium L. var. californica [A. Gray. |
| Oenothera viridescens Hook. (= O. cheiranthifolia Hornem.). | |

A small group of plants which have entered southern California directly from lower California inhabit a narrow strip along the coast. Some barely pass the border; few penetrate very far within it, and the last one disappears at Santa Barbara. However, the plants below form a southern element of invasion and must be mentioned in this connection.

| | |
| --- | --- |
| Acalypha californica Benth. | Frankenia Palmeri Wats. |
| Agave Shawii Engelm. | Isomeris arborea Nutt. |
| Arctostaphylos diversifolia Parry. | Iva Hayesiana A. Gray. |
| Baccharis sarothroides A. Gray. | Opuntia prolifera Engelm. |
| Beloperone californica Benth. | » serpentina Engelm. |
| Cereus Emoryi Engelm. | Simondsia californica Nutt. |
| Cneoridium dumosum Hook. | Viguiera laciniata A. Gray. |
| Dithyrea californica Haw. | |

## 6. Western Desert Regions.

*General Remarks.* A physiographic, floristic and meteorologic study of western North America has resulted in the delimitation of two great desert regions. These may be designated as the Sonora-Nevadan Desert and the Chihuahuan Desert. The Sonora-Nevadan desert region embraces portions of Utah, Idaho, Oregon, Washington, Nevada, California, Arizona, Baja California, Sonora and Sinaloa. The northern portion of the region is mainly comprised in the Great Basin and includes the beds of a number of ancient lakes and the surviving Great Salt Lake. Other special physiographic features of interst in this connection are the areas which bear the name of Snake River Desert of Idaho; the sage plains of Washington; the lava beds of Oregon; the Ralston Desert in Nevada; Death Valley; Mohave, Colorado, Salton deserts in southern California and Arizona; the Painted Desert in Ari-

zona and New Mexico; and the Sonora Desert in Mexico. The southern portion of the region consists of a series of slopes and terraces with many ranges of hills and mountains with peaks of same altitude. Along the shores of the Gulf of California and of the Pacific Ocean, the desert area includes the entire surface to within a few feet of the water's edge and the xerophytic vegetation of the plains comes into direct contact with the mangrove and strand flora.

The sources and distribution of the floral element of this great western desert region now claim our attention. The northern desert, occupying portions of Washington, Oregon and Idaho, is a huge sage brush plain, broken by numerous low mountain ranges having little or no timber. Between these mountains are the desert sinks and "sleek deserts" (alkaline stretches entirely destitute of vegetation). All except the "sleek deserts" are covered with a shrubby growth of sage, salt bushes and greasewood.

Pine Forest range in Oregon has on the highest elevations a scanty growth of pine, *Pinus albicaulis* as found at the extreme upper limit of timberline on Mt. Shasta, California (Fig. 7), while neighboring mountains such as Steins Mountain have no pines at all. The latter have much more of *Juniperus virginiana* than the former. *Pinus ponderosa* var. *scopulorum*, *Populus tremuloides*, *P. trichocarpa*, constitute the remainder of the arborescent species of the northern Great Basin. The desert regions of the north are very different from those of Arizona and these differences are sufficient to delimit a northern phytogeographic area. There is a very noticeable absence of the creosote bush *Larrea mexicana*, and the various species of *Cactaceae*, their place being taken by the spiny salt bush *Atriplex confertifolia*, bud sage *Artemisia spinescens*, and black sage *Artemisia tridendata*. There is, however, a strong similarity. The ephemeral spring vegetation of Polemoniaceae, Cruciferae and Boraginaceae (*Gilia*, *Amsinckia*, *Eritrichium*) corresponds very closely, as far, as it goes, with the conspicuous fugacious spring plants of the Arizona desert [1]).

No portion of the central desert region (Nevada and Utah) is destitute of some vegetation, even in the driest seasons, excepting only the alkali flats, which are of limited extent. Even those have a scattered growth of *Sarcobatus*, or *Halostachys*, surmounting isolated hillocks of drifted sand. To the absence of trees, there seems to be but a single exception in the valley of the Truckee River where *Populus monilifera* (= *P. deltoides*) and *P. trichocarpa* grow. The turf forming buffalo, or grama grasses of the plains are absent, but they are replaced by sparsely scattered tufts of grasses that perish with the early summer heats. *Halostachys occidentalis*, *Sarcobatus vermiculatus*, abundant as shrubs in the region, are accompanied by *Salicornia herbacea*, several species of *Suaeda*, certain chenopodiaceous plants and the grasses *Distichlis maritima* (*Brizopyrum spicatum*) and *Spartina gracilis*. The minor

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1) GRIFFITHS, DAVID: Forage Conditions of the northern Border of the Great Basin. Bureau of Plant Industry (U. S.). Bulletin No. 15 and Bulletin No. 38.

flora is marked by senecioid and ligulate Compositae, species of *Astragalus*, *Oenothera*, *Gilia*, *Hydrophyllaceae* and annual *Erigoneae*[1]). The mountains

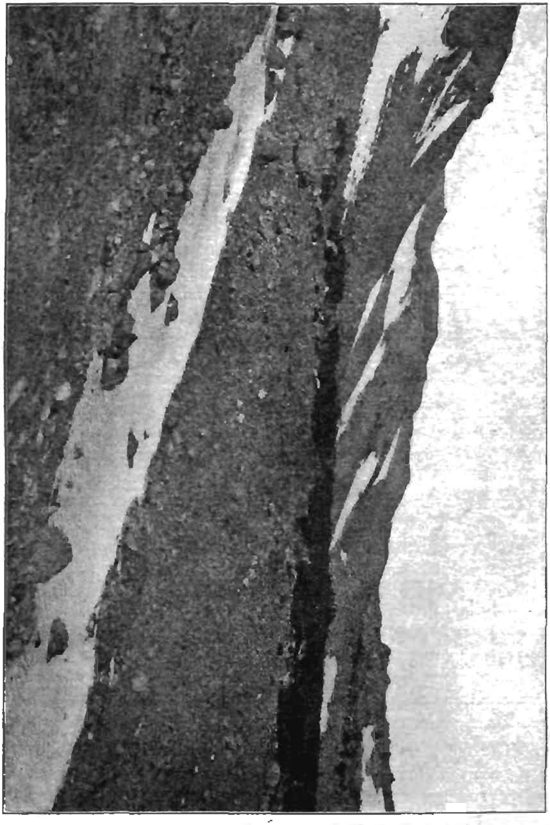

Fig. 7. *Pinus albicaulis* Engelm. extending as a Tongue to the Extreme Upper Limit of Timberline on Mount Shasta, California. After North American Fauna (16 Plate IV) from photograph by J. S. Diller.

are as destitute of trees as the valleys. *Pinus monophylla*, *Juniperus occidentalis* (5000—7000 feet), *Cercocarpus ledifolius* (6000—8000 feet), *Populus tremuloides* (in upper canyons), *Populus balsamifera* var. *angustifolia*, *Pinus flexilis*,

1) WATSON, SERENO: Botany, U. S. Geological Exploration of the Fortieth Parallel. 1871.

*Pinus Balfouriana*, *Picea Engelmanni*, *Abies grandis*, form the list of trees which occur on the central mountain ranges, associated with which are *Ceanothus velutinus* (7000—9000 feet), *Ribes cereum*, *Symphoricarpos montanus*, *Prunus demissa*, *Ribes irriguum*, *Sambucus glauca*, *Cornus pubescens* (*C. occidentalis*), *Crataegus rivularis*, *Alnus incana*. Among the herbaceous species there is a marked predominance of certain orders, genera or section of genera, mostly perennials. The number of alpine and subalpine plants is proportionately very large.

The alpine and subalpine flora of the higher mountains of the Great Basin is largely a derivative one with the admixture of some purely endemic forms which have originated as species since the last great ice age, when, as we have shown in discussing the origin of the alpine flora of the Sierra Nevada Mountains, it was indicated that a communication probably existed across Nevada and Utah from the Rocky Mountains to the Sierra Nevada ranges by way of the numerous desert mountain ranges. Under their present condition of isolation, the migration of these species would be impossible, but when the present boreal flora was depressed nearly or quite to the base level of the mountains, an excellent route for migration was presented[1]). The boreal element of the mountain flora is clearly recognizable in the lists of alpine and subalpine plants which have been presented. The plants of the alpine region and of the subalpine region of the higher mountains of the Great Basin will be found in ENGLER's lists[2]).

*Great Basin Elements*. A critic study of the plant life of the Great Basin has shown it to consist of a southward extension of boreal plants on the high mountains with an admixture of southern forms resulting from an intrusion or migration of representatives of the Sonoran flora some of which, from long residence in the region, have undergone enough modification to be recognized as distinct sub species, or even species. The arid species of the valleys and lower mountain slopes are species which extend northward even from Mexico through the states of Sonora and Chihuahua. This southern or Sonoran element will now be considered after which attention will be given to some of the peculiarly endemic Great Basin species, which probably originated in the region under consideration. As examples of the contact of the Mexican flora with that of the Great Basin may be mentioned the *Yucceae*. In all probability the Mexican table-land is the original home of the entire group of Yuccas, and such tree forms, as *Yucca Treculeana* in the Chihuahuan Desert (Fig. 8), indicate the high degree of development to which such forms have reached.

The following species of Yucca which constitute an element of the Basin flora may, therefore, be looked upon as originally of southern derivation, viz., Yucca Schottii (Utah), Yucca baccata (Utah, Arizona, N. Mexico), Yucca angustissima (S. E. Nevada, N. W. Arizona), Cleistoyucca

1) See ante page 250; 256.

2) ENGLER, A.: Die pflanzengeographische Gliederung Nordamerikas 1902: 92.

arborescens (S. Nevada, S. E. California), Yucca mohavensis (S. California, S. Nevada), Hesperoaloë parviflora (Arizona), Yucca radiosa, Yucca macrocarpa (S. Arizona, S. New Mexico), Yucca brevifolia (S. Arizona).

The papaveraceous genus *Hunnemannia* of Mexico is related to the genus *Eschscholtzia* of California and Great Basin. *Dalea* is represented by numerous species on the table-land of Mexico and by eleven species in Arizona and the

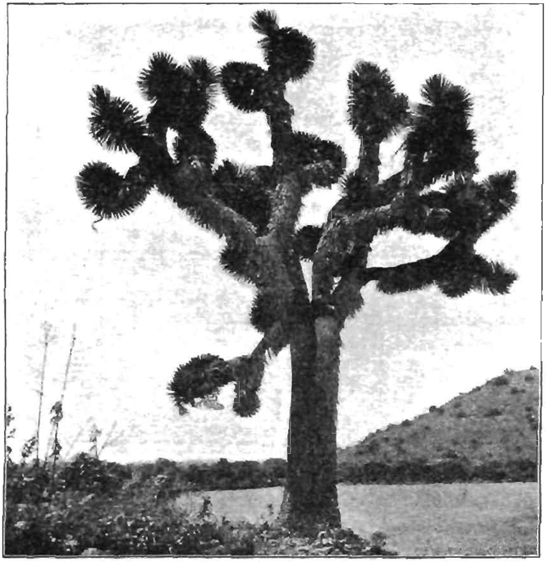

Fig. 8. *Yucca Treculeana* Carr. Chihuahuan Desert Region, Mexico, as seen near the Pyramid of the Sun northeast of the City of Mexico. After Contributions from the U. S. National Herbarium V, Plate XXXVIII.

Great Basin. Likewise *Larrea mexicana* is common. Among the *Rosaceae*, we find *Coleogyne*, *Cowania*, *Fallugia* only in Mexico, the Great Basin and California, *Cercocarpus* perhaps also is a Mexican form of extensive northern distribution. *Brickellia* a genus of the *Compositae-Eupatoriaceae* which includes many species in Mexico is represented by one species in the Atlantic states and one also in Texas and the Great Basin. As representatives of the southern contingent (not necessarily Mexican) may be mentioned:

## Alkali formation.

Thelypodium Nuttallii (= T. torulosum), Cleomella parviflora.

### *Xerophyte formation.*

Astragalus Nuttallianus, lentiginosus, dentatus, [scapoideus, albicaulis.
Gilia inconspicua.
Eriogonum gracile, plumatella, deflexum, inflatum, cernuum, angulosum. Wrightii.
Chorizanthe brevicornu, rigida.
Tetradymia spinosa.
Anisocoma acaule.
Stephanomeria (Ptiloria) minor (= S. tenuifolia).
Glyptopleura marginata.
Eschscholtzia californica.
Argemone mexicana.
Mirabilis californica.
Oxybaphus angustifolius.
Sphaeralcea Emoryi.
Eritrichium micranthum, angustifolium.
Piptocalyx (Krynitzia) circumscissus.
Pentstemon Palmeri.
Abronia fragrans, turbinata.
Townsendia strigosa.
Aristida purpurea.
Myosurus aristatus.
Lepidium flavum, Fremontii, alyssoides.
Thysanocarpus elegans.
Capsella divaricata.
Lupinus pusillus.
Hosackia (Lotus) Heermanni.
Psoralea lanceolata.
Malvastrum Munroanum (= M. coccineum).
Sida hederacea.
Cymopterus montanus, pterocaryum.
Amsinckia lycopsoides.
Nicotiana attenuata.

The following alkaline species have been found, so far as known only within the limits of the Great Basin and, therefore, form an *endemic element:*

Arabis longirostris, Thelypodium sagittatum, Cleomella plocasperma, Astragalus pterocarpus, Ivesia (Horkelia) Kingii, Aster Nuttallii, Aplopappus (Pyrrocoma) tenuicaulis, Crepis Andersoni, Lycium Andersoni, Erythraea Nuttallii, Monolepis pusilla, Atriplex (Obione) phyllostegia, A. (O.) pusilla, Kochia prostrata, Spirostachys (Halostachys) occidentalis, Fimbristylis thermalis. But five species of aquatic plants can be considered to be peculiar to the Great Basin occupying the margin of lakes and streams, marshes, etc. though the localities in which they are found may often be to a considerable extent alkaline: Nasturtium (Roripa) lyratum, Selinum Kingii, Potamogeton marinus, Scirpus nevadensis, Carex Watsoni[1]).

The remaining plants of the valley flora including a large proportion of endemic species are those which occupy the drier sandy or gravelly portions of the valleys and the foothills and are consequently subject to a greater extreme of heat and drought. Many of them are low, or dwarfed, annuals, often varying much in size and habit with the circumstances of their growth, usually starting with the rains of autumn, flowering in early spring and hastening to a quick maturity. With the first heats of summer, they vanish. Others are stouter and hardier, more or less woody biennials, or perennials, springing from bulbs, roots, or rootstocks and persisting longer until July under the protection of the shrubs which remain.

A large number of (one third) peculiarly desert species, are strictly confined to the Great Basin and on the whole southern, quite a large number extending into the Mohave and Colorado deserts and a few into New Mexico or even western Texas. Many of the endemic species of the drier valleys and foothills are described in Part IV, Chapter III. In the absence in many cases of any forest growth to indicate the limit of arborescent vegetation, it is

1) WATSON, SERENO: Botany United States Geological Exploration of the Fortieth Parallel. Clarence King: 1871. General Report.

difficult to arrange the species zonally, because the flora of any mountain locality is greatly influenced by a warm and sunny exposure, or the opposite. The endemic mountain species of the Basin are described in Part IV, Chapter III, 3.

The Great Basin has supplied many species to the Rocky Mountain region and beyond to the east, while a similar element is found in Oregon and Washington and western Texas. These elements have been previously described and a discussion of them will be omitted at this place. Looking at the Basin flora, as a whole, it appears to be to a considerable extent a distinct one. Though the position of the territory would rather indicate as probable an intermingling of the surrounding floras, of the Californian with that of the Rocky Mountains, and of the extreme northern descending along the mountain ranges, with that of the deserts of Arizona, spreading northward in the valleys, yet it has a marked character of its own. This consists partly in the absence of many of the peculiarities of the surrounding floras. A very large portion of the Pacific species, not only arborescent, but shrubby and herbaceous, stop abruptly upon the eastern slope of the Sierras and do not reappear eastward. A like demarcation is shown on the eastern side at the base of the Wahsatch Mountains by the intermediate accession of new orders and species, characteristic of the eastern flora. Again many of the forms prevalent farther south are wanting, or appear only on the borders of Nevada and Utah, as most of the Cactaceae and of the Daleas and other large leguminous genera and suborders, characteristic rutaceous, zygophyllaceous species, the Cucurbitaceae, Loranthaceae, a large portion of the Solanaceae, Euphorbiaceae and Nyctaginaceae. The mingling with northern species is necessarily more intimate. The general preponderance of senecioid composites (*Artemisia tridentata*, the prevailing representative) and the marked number of chenopodiaceous genera and species many of which do not extend beyond the limits of the Basin, make the flora a singular one and warrant designating the district as one of Artemisias and chenopods. The abundance of species of *Astragalus*, *Eriogonum*, *Oenothera*, *Pentstemon* and *Phacelia* is also more or less distinctive. The southwestern portion of the Sonora-Nevadan Desert includes the limits of two very distinct districts, comprising the territories of the Mohave Desert and of the Colorado Desert. The Mohave Desert district, may be looked upon as belonging to the Great Basin Region, while the Colorado Desert has greater affinities with the desert flora of Mexico (see the map: Sonoran Desert region).

*The Colorado and Mohave Deserts.* These have many plants which are common to both, but each possesses also a distinctive flora. It appears from the table following that the desert genera fall into three nearly equal groups, namely, those which are found in one or the other of the two territories; and those which occur in both of them. Two sections of each are distinguished; a northeastern section for the plant whose extensions are into Nevada, Utah and the Great Basin; and a southeastern section to include the genera whose extensions of range are into northern Mexico. A number of species have diverse ranges and the genera to which they belong are indicated. Genera

which are represented by species which also extend into the peninsula of Lower California are marked by an asterisk *.

Genera peculiar to the Mohave-Colorado Deserts 1).
Genera abundant und widely distributed in spread letters; rare and local in italics.

| Colorado Desert. | Mohave Desert. | Both. |
|---|---|---|
| Northeastern Element. | Northeastern Element. | Northeastern Element. |
| Astephanus. | *Actinella*. | Anisocoma. |
| Southeastern Element. | Amsonia. | Grayia. |
| Wedelia. | Atrichoseris. | Piptocalyx. |
| *Argyrothamnia (= Ditaxis). | *Bouteloua. | *Tricardia*. |
| *Ayenia*. | Cleomella. | Southeastern Element. |
| *Beloperone. | *Eurotia. | Acamptopappus. |
| Boerhaavia. | *Forestiera* (= Adelia). | Achyronichia. |
| * *Calliandra*. | Glossopetalon (= Forsellesia). | Baileya. |
| Cercidium. | Glyptopleura. | Bernardia. |
| Chloris. | Kochia. | Cladothrix. |
| * *Condalia*. | Lygodesmia. | Hilaria. |
| Dicoria. | Monoptilon. | *Krameria. |
| *Fagonia. | Phellopterus. | *Larrea. |
| Fouquiera. | Purshia. | Mohavia. |
| *Hibiscus. | Stanleya. | Nolina. |
| *Horsfordia. | *Salazaria. | Thamnosma. |
| *Hoffmanseggia. | * *Syntrichopappus*. | *Trichoptilium*. |
| *Hofmeisteria. | Southeastern Element. | |
| *Hyptis. | *Canotia*. | |
| *Leptochloa. | Coleogyne. | |
| *Martynia*. | *Fallugia*. | |
| | Psilactis. | |
| | Indefinite. | |
| Calycoseris. | Sphaeralcea. | *Porophyllum. |
| Chylisma. | *Olneya. | Sesbania. |
| *Dalea. | *Parkinsonia. | * *Triodia*. |
| *Ephedra. | *Pectis*. | Tribulus. |
| Petalonyx. | *Peucephyllum. | Trixis. |
| Prathyrotes. | *Palafoxia. | * *Washingtonia* (= Neowashingtonia). |

1) PARISH, S. B. A Sketch of the Flora of southern California. The Botanical Gazette XXXVI: 218.

It is to be noted that *Astephanus*, the single northeastern genus peculiar to the Colorado Desert, is known from a single collection. All the others are southeastern, and all but ten extend into Lower California. On the other hand, *Canotia* and *Fallugia*, two of the southeastern plants of the Mohave Desert are found only in the Providence Mountains, which may prove to be included in the Colorado Desert region. Only four of the peculiar Mohavan plants have been reported from Lower California.

Geographic affinities may be exhibited by different species of certain genera which are differently represented in each territory, as shown in the following table:

| Colorado Desert. | Mohave Desert. |
|---|---|
| Agave deserti Engelm. | Agave utahensis Engelm. |
| Aster Orcuttii Aut. | Aster tortifolius A. Gray. |
| Cassia Covesii A. Gray. | Cassia armata Wats. |
| Coldenia canescens DC. | Coldenia Nuttallii Hook. |
| » Palmeri A. Gray. | |
| Dalea (Parosela) Emoryi A. Gray. | Dalea Fremonti Torr. |
| » Parryi T. & G. | » polyadenia Torr. |
| » Schottii Torr. | |
| » spinosa A. Gray. | |
| Gilia bella A. Gray. | Gilia dichotoma Benth. |
| » Schottii Wats. | » Matthewsii. |
| » tenuiflora Benth. | » setosissima A. Gray. |
| Lupinus arizonicus Wats. | Lupinus brevicaulis Wats. |
| Pentstemon ambiguus Torr. | Pentstemon glaucus Graham. |
| *Phacelia micrantha* Torr. | *Phacelia Ivesiana* Torr. |
| Psathyrotes ramosissima Torr. | Psathyrotes annuus Nutt. |

All the species in the Colorado column have southeastern affinities; all those in the Mohave have northeastern affinities. In the former, ten out of sixteen extend into Lower California. The facts already accumulated indicate that in the Colorado Desert the Sonoran flora which extends over the entire desert area is slightly modified by any other. The Mohave desert flora, on the contrary, shows a marked influence from the Great Basin flora. The limit to which this extends appears to be defined by the Chuckawalla Mountains. The difference in the character of the two floras is only in part due to climatic causes, but is largely influenced by the topography of the region. In the one case, a current of migration was able to pass up, encountering no physical barriers, from Arizona and Lower California into the Colorado Desert; in the other a current from eastern Utah and Nevada entering the Mohave desert and Death Valley, a part of the desert, would meet no considerable obstacle until it reached the San Bernardino Range and its continuation.

The geographic relationship of the Death Valley flora is clear. The arid plants of the valley almost without exception are species which extend south-

ward into Mexico and which are there confined to the arid interior plateau of that country. The course of migration has been perhaps through the Mexican states of Chihuahua and Sonora via, the southern part of the Great Basin, into Death Valley and the Mohave Desert [1]).

The Desert of the Little Colorado, or Painted Desert, is a deep basin on top of the great Colorado Plateau. From its topographic position, the only possible channel through which the fauna and flora of the Painted Desert could have reached this territory during existing climatic conditions is by way of the Grand Canyon of the Colorado. The inference is that the life of this desert is derived from the deserts of western Arizona, and that it came by the round-about way of the Grand Canyon of the Colorado. It behooves us, therefore, to examine briefly the elements of the flora of this great depression (6000 feet in depth). This canyon has ledges, terraces and mesas, barren crags and grassy slopes, lofty mountains and deep valleys, cool hillsides clad in forests of balsam fir, and hot bottoms filled with subtropic thickets; it has arid stretches of sand bearing a scattered growth of cactus and yucca, marshes and springs, that never become dry and are hidden by the verdure of a multitude of plants requiring a moisture-laden atmosphere for their existence.

Descending from the plateau level to the bottom of the canyon a succession of belts is encountered equivalent to those stretching from the coniferous forest of northern Canada to the cactus plains of Mexico. They result from the combined effects of altitude and slope exposure, the effects of the latter being here manifested in an unusual degree. Where the walls of the canyon face north, or northeast, the uppermost tree-belt consists of *Pseudotsuga Douglasii* and *Abies concolor*. Below this is a belt of pines, *Pinus ponderosa*, succeeded in turn by a belt of junipers and piñon, usually more or less mingled with pines. Immediately below the piñon belt is a belt which corresponds in the main to the Desert of the Little Colorado; but since it has humid as well as arid areas, forms of vegetation unknown on the desert interrupt its stretches of cactuses, yuccas and greasewood. Still lower down another belt is encountered which may be recognized by the presence of huge cactuses, arborescent opuntias, agaves and many plants characteristic of the Lower Colorado and Gila regions [2]) together with subtropic humid forms and a certain percentage of species not found elsewhere.

Situated at the western edge of the painted Desert stands San Francisco Mountain, a peak, the flora of which demands a passing notice, rising as it does in the southern part of the Colorado Plateau to an elevation of 12,794 feet (3900 m). Two trees *Picea Engelmanni*, *Pinus aristata* reach timber line and become stunted. They are accompanied by a number of hardy little plants which attain their maximum development here:

1) Coville, F. V.: Botany of the Death Valley Expedition. Contributions U. S. National Herbarium IV (1893): 31—33.

2) Merriam, C. Hart: Results of a biological Survey of the San Francisco Mt. Region and Desert of the little Colorado, Arizona. North American Fauna No. 3, 1890: 33.

Arenaria biflora var. carnulosa, Cerastium alpinum var. Behringianum, Corallorhiza multiflora, Draba aurea, Epilobium saximontanum, Gentiana barbellata var. tenella, Heuchera rubescens, Luzula (Juncoides) spadicea var. parviflora (= L. parviflora), Pedicularis Parryi, Phleum alpinum, Potentilla dissecta, Primula Parryi, Saxifraga debilis, Sedum rhodanthum, Veronica alpina.

Above timber line 11,500 feet (3500 m) are found on the bleak and storm-beaten summit of San Francisco Mountain the following alpine plants:

Androsace septentrionalis, Arenaria verna, Cerastium alpinum, C. arvense, Cystopteris (Filix) fragilis, Festuca brevifolia, Oxyria digyna, Polemonium confertum, Sagina Linnaei (S. Saginoides), Saxifraga decipiens (*caespitosa), S. debilis, S. flagellaris, S. nivalis, Sibbaldia procumbens, Silene acaulis, Stellaria umbellata (S. baicalensis), Thlaspi alpestre, Trisetum subspicatum.

The spruce belt 9200—10,500 feet (2800—3200 m) is occupied by *Picea Engelmanni* and *Pinus aristata* with *Aquilegia chrysantha*, *Lathyrus arizonicus*, *Mertensia paniculata*, *Moneses uniflora*, *Pentstemon glaucus* var. *stenosepalus*, *Pyrola chlorantha*, *Ribes setosum*, *Solidago multiradiata*, *Zygadenus elegans*. The fact of present interest is that many of the plants here enumerated, as growing in the spruce zone of this mountain, are equally characteristic of the higher Alleghanies, the Rocky Mountains and northward.

The next belt below 8200—9200 feet (2500—2800 m) is characterized by *Pseudotsuga Douglasii*, *Pinus flexilis* var. *macrocarpa*, *Populus tremuloides* and such smaller plants as **Actaea spicata*, *Berberis repens* (= *B. aquifolium*), *Ceanothus Fendleri*, *Gentiana affinis*, **Geum triflorum*, **Potentilla* (*Dasiophora*) *fruticosa*, *Ribes Rusbyi*, **Viola canadensis* var. *scopulorum*. Those marked with an asterisk have a wide range in the Canadian flora of the east and north. *Ceanothus Fendleri* may be safely regarded, as the western representative of *C. ovatus*, which ranges eastward from the Rocky mountains to Vermont.

The pine belt 7000—8200 feet (2100—2500 m) has one characteristic tree, *Pinus ponderosa*, which forms an unbroken forest. As a tree, it ranges at middle elevations from the highlands of western Texas and northern Mexico, northward along the Rocky Mountains and the Sierra Nevadas to the dry interior of British Columbia in latitude 51, 30 N. avoiding the region of excessive downfall along the coast from northern California northward. Among the more conspicuous species occurring in the pine belt of San Francisco Mountain, and having a more or less coincident distribution with the pine are: *Campanula Parryi*, *Frasera speciosa*, *Gilia aggregata* var. *attenuata*, *Oxybaphus* (*Allionia*) *angustifolius* (= *linearis*), *Oxytropis* (*Aragallus*) *Lamberti*, *Pentstemon barbatus* and *P. Torreyi*[1].

The distinctive trees of the piñon belt 6000—7000 feet (1800—2100 m) are *Pinus edulis*, *Juniperus occidentalis* var. *monosperma*, and the rare *Juniperus pachyphloea*. Several large shrubs are present: *Berberis Fremonti*, *Rhus aromatica* var. *trilobata*, *Spiraea discolor* var. *dumosa*. Near the Grand Canyon of the Colorado and again at Walnut Canyon, these shrubs are joined by *Cowania mexicana*, *Spiraea millefolium*, *Robinia neomexicana*, *Juniperus californica* var. *utahensis*, *Fallugia paradoxa*, while *Yucca angustifolia* (= *Y. glauca*)

1) MERRIAM, l. c.

is in places replaced by *Yucca baccata.* Both the piñon and the cedar occupy elevations of corresponding temperature in the arid lands from western Texas through New Mexico, Arizona and north to central Colorado, and the cedar extends westward to southern California. Closely related and strictly representative forms extend northward through the Great Basin to the plains of the Columbia; some other species push northward over the Great Plains as well as the interior basin.

The desert flora[1]), the origin of which has been previously discussed (altitude 4000—6000 feet; 1200—1800 m), is scattered and scanty, and consists of such genera, as *Atriplex*, *Sarcobatus*, *Oxytaenia*, *Tetradymia*, *Yucca*, and cactuses of several genera, while in the rainy season *Bouteloua*, *Lupinus capitatus*, *Mirabilis multiflora*, *Riddellia tagetinae* and *Zinnia grandiflora* are conspicuous.

South of the mountain ranges, which embrace San Francisco Mountain, a practically pure Mexican flora may be said to occur. Over against the valley, of the Gila River, *Cereus giganteus* 30—50 feet high is found. Also *Fouquiera*, species of *Agave*, *Dasylirion*, *Canotia*, *Mimosa*, *Acacia*, *Calliandra*, *Baccharis* and *Tessaria borealis*. Near Tucson, Arizona, the previously abundant Chenopodiaceae disappear to be replaced by numerous Cactaceae and *Larrea mexicana*. The northern boundary of many Mexican forms is found in the ranges of mountains which extend northwest and southeast, while between the Gila River and the Rio Grande, the Mexican types are predominant[2]).

The time element enters into a consideration of the origin of the different elements of the Great Basin and desert floras of the southwestern states. Topographically the Great Basin is an enclosed surface diversified by hundreds of basins suitable for holding broad lakes, but the present aridity of the region precludes their being occupied by perennial water bodies. In many instances, the annual rainfall in these desert basins is so meager, that it is at once absorbed by the thirsty soil, or returned to the atmosphere as vapor, and not even ephemeral lakes are formed. Should the Great Basin and contiguous regions experience a change of climate of such a nature that the rainfall would be increased, or evaporation diminished, the most obvious result would be the appearance of lakes in the valleys that are now either dry throughout the year, or hold playa lakes, and the expansion of perennial lakes[3]). The study of the surface geology of the Great Basin has shown that a more humid climate of the nature just suggested was prevalent in the region at a time not remote. The streams from the mountains increased in volume many channels were occupied by flowing water, that are now dry throughout the year, and large lakes denominated respectively Lahontan and Bonneville covered a large

1) See ante page 285—291.

2) ENGLER, A.: Versuch einer Entwicklungsgeschichte der Pflanzenwelt, II. Theil, 1882: 219.

3) Since the above was written, the Colorado River broke through its banks and flooded the lower part of the Colorado Desert, during the winter of 1904—1905, producing a large inland lake, the Salton Sea. See MACDOUGAL, D. T. The Desert Basins of the Colorado Delta. Bulletin American Geographical Society. Dec. 1907.

extent of territory. These lakes existed during the Pleistocene and we have every reason to believe that the desert flora which now reigns supreme was not then widely spread, but its place was taken by a vegetation more typic of a humid climate with its forests and other plants dependent on a more abundant rainfall. Two elements of the desert flora may be distinguished, viz., a Great Basin element and a Mexican element. It is probable that the differentiation of the Great Basin element began before the great glacial period and was preserved and still further developed, as an arid type during the period of more humid climate in the enclosed valleys, such as Death Valley and in the Mohave Desert region cut off from the prevailing source of rain supply and on the drier hillsides. With the gradual coming on of a dry climate and the disappearance, or contraction of the Pleistocene lakes in all probability the endemic Great Basin element of the present flora extended its range northward and downward into the areas left bare by the disappearance of the fresh water lakes. A present day illustration of this succession is afforded by the Salton Sea which was formed in the Colorado Desert by the diversion of water from the Colorado River. The freshwater of the lake dissolved out much of the alkali of the new shore soil, and as the water recedes, since the break in the bank of the river has been closed by engineers, the alkali plants occupy the shore line of recession with difficulty. Many thousands of the arrow weed, *Pluchea sericea*, and cat tail, *Typha angustifolia*, as well, as other species which occupied the shores of the new lake find it difficult to maintain their hold as the shore soil becomes drier and more alkaline, so that it is only a question of time when the freshwater vegetation will have disappeared and will have been replaced by other vegetation, as noticed by MacDougal [1]).

At about this time, the Mexican element migrated into the Basin and as the plants constituting it were already from their origin in the ancient deserts of Mexico suitably adapted both morphologically and physiologically to dry soil and a dry climate, they naturally spread and usurped much of the territory formerly controlled by a more humid climate and covered by a more mesophytic vegetation. In all probability, therefore, the spread of the Great Basin element began in the Pleistocene and has continued ever since and that the Mexican element was introduced into the region at the close of the Pleistocene at a period subsequent to the disappearance of the Pleistocene lakes.

The desert flora, on the other hand, in all probability, entered southern California before the Pleistocene for we have evidence of this in the presence of many typic desert plants in southern California, not present in the Great Basin, and yet the course of their migration would have been more direct into the Great Basin region. In this statement, we refer to the flora south of the San Bernardino range; for from what has preceded in a discussion of the flora of the Mohave Desert, there is a clear evidence of its affinity with the

1) Year Book of the Carnegie Institution of Washington, 1908: 56—57.

Great Basin flora and is perhaps older to the region in point of time than the flora of the Colorado Desert, for from a previous statement, it is not presumptious to suppose that the Mohave desert supplied to the drying Great Basin many of its most typic plants.

*Flora of Northern Mexico.* The flora of northern Mexico is characterized by the absence of thirty nine natural orders, which are represented in central and southern Mexico, the absent orders being essentially tropic or consisting of hygrophilous plants. Three orders, the Frankeniaceae, Elatinaceae and Santalaceae, represented by one species each, are not known to occur in the central and northern positions of the country. The Cruciferae, Polygalaceae, Malvaceae, Malpighiaceae, Leguminosae, Crassulaceae, Onagraceae, Cactaceae, Compositae, Asclepiadaceae, Polemoniaceae, Hydrophyllaceae, Boraginaceae, Convolvulaceae, Solanaceae, Scrophulariaceae, Labiatae, Nyctaginaceae, Amarantaceae, Chenopodiaceae, Polygonaceae, Euphorbiaceae, Cupuliferae, Coniferae, Amaryllidaceae, Gramineae, and Filices are the orders predominant in the number of species. Such genera as *Beschorneria*, *Fouquiera* and *Nolina* have their center in north Mexico and probably originated there. The number of Mexican species extending northward west of the Mississippi is almost double that extending northward east of that river. The extensions into eastern North America are largely south Mexican plants and not north Mexican. Such genera as *Magnolia*, *Asimina*, *Tilia*, *Robinia*, *Liquidambar*, *Ilex*, *Diospyros*, *Bumelia*, *Ulmus*, *Morus*, *Ostrya*, *Carpinus* and *Carya* (*Hicoria*) are absent from the Pacific forests, but all these genera are represented in Mexico, yet, so far as we know, only four out of the fourteen in north Mexico. Sometimes the species of eastern North America and in the mountains of south Mexico, are identic *Liquidambar styraciflua*, *Ostrya virginiana*, and *Carpinus americana*. In the belt of oaks in south Mexico according to ENGLER are found *Ulmus*, *Alnus*, *Clethra*, *Cornus*, *Viburnum*, *Deutzia*, *Triumfetta*, *Rubus*, *Vitis*, genera which occur in the Atlantic states of the American Union, and this relationship between two widely separated floras extends to many genera of herbaceous plants: *Thalictrum*, *Ranunculus*, *Anoda*, *Hypericum*, *Desmodium*, *Rhexia*, *Cuphea*, *Lobelia*, *Salvia*, etc. Many of the species inhabiting pinewoods belong to genera which are widely prevalent in the extra tropic portion of the northern hemisphere: *Veratrum*, *Salix*, *Trifolium*, *Arenaria*, *Polygala*, *Helianthemum*, *Castilleia*, *Gerardia*, *Chelone* etc.

There is, therefore, ample evidence that north Mexico is the center of a special xerophilous flora which, there are good grounds for assuming originated in this area, though this flora by migration now has considerable northward and southward extensions. A considerable part of the flora of California, still more of Nevada, Utah and western Texas and, yet more, that of Arizona and New Mexico may be regarded as a northward extension of the flora of the Mexican plateau [1]).

1) HEMSLEY, W. BOTTING: Botany in Biologia Centrali-Americana, Vol. IV, 1888: 306—315.

The Edwards Plateau region in central Texas an area roughened by erosion, exposing the limestone strata to the reception of rainfall is a meeting ground for species from the Atlantic forest, the southern Rocky Mountains and from the north Mexican highlands. Such Mexican plants are *Juglans rupestris*, *Morus celtidifolia*, *Arbutus xalapensis*, *Sophora secundiflora*, *Bumelia lanuginosa*. The trans-Pecos territory is characterized by a covering of strongly xerophytic chaparral which embraces the northern Mexican plateau, the arid plateaus of New Mexico, Arizona and southern California. It is floristically different from the Rio Grande chaparral, which represents a northern tongue of the great coastal scrub extending southward, for the trans-Pecos chaparral represents the northern extremity of the Mexican plateau flora. As a consequence of this, we find the Mimoseae and Caesalpineae represent less than 10 per cent of the species, individuals occur less abundantly, and excepting *Prosopis juliflora* are different species from those of the Rio Grande plain. A more striking array of ecologic types is found in the species of this formation, as illustrated in the *Ephedra*-type, the felt-covered *Eurotia*- and *Croton*-types, the resin containing *Larrea* and *Flourensia*, and the thorny-stemmed *Fouquiera*. About thirty species are more or less prominent constituents of the chaparral of the trans-Pecos area. *Larrea mexicana*, the Mexican greasewood, is characteristic of high gravelly mesas and of bolson deserts extending even to the alkali soils of such basins. All of these facts presented above demonstrate the predominant Mexican character of the plant formations described above[1].

*Cactus-Vegetation.* The Cactaceae afford an interesting proof of the fact that the Mexican tableland forms a center of origin of many peculiar plant forms. The headquarters of the family is found in Mexico and one is forced to believe that the family had its origin here[2]. The territory richest in species is in the neighborhood of Pachuca, Tula, Queretaro, Guanajuato, San Luis Potosi and northward to Saltillo, Monterey, Montclova and Laredo on the Rio Grande River. Less rich, but by no means poor in species, are the northern states of the Mexican Republic, Chihuahua, Coahuila and Sonora, the last is connected with the richest territory of the United States in cacti, viz., that covered by the states of New Mexico, Arizona and California, especially in their southern portions and Texas. Lower California is also rich in forms. The distributional headquarters is especially rich in species of the genera *Mamillaria* and *Echinocactus*. In the moist valleys of southern Mexico, *Pilocereus* is regnant, only a single species, *P. Schottii*, is present in northern Mexico. Such small genera as *Ariocarpus*, *Anhalonium*, *Pelecyphora*, *Leuchtenbergia* are found at headquarters. The genus *Cereus* has its development north of the center, for example, *C. giganteus*, on the Rio Gila, and such species, as *Cereus pectenaboriginum* (Fig. 9) show the prominence which plants of this character have in the landscape. The Opuntias are numerous both at the center and in the

1) Bray, W. L.: The ecological Relation of the vegetation of western Texas. Botanical Gazette XXXII: 275 (1901).

2) Schumann, K.: Gesamtbeschreibung der Kakteen 1899 21.

United States. From the central point of distribution, the number of species rapidly diminishes in a north and east direction.

Fig. 9. *Cereus pecten-aboriginum* Engelm. Lower California District, Mexico. After Contributions U. S. National Herbarium V, Plate LVIII.

The Central American states of Guatemala and Costa Rica are according to our present knowledge very poor in cactuses. This is evidently due to the fact that these states were originally covered with a dense forest, but on the dry interior plains species of *Peireskia* abound, and such epiphytic forms of the family as *Phyllocactus* and *Rhipsalis* occur here in the moist tropic forest. The writer has seen at Orizaba abundant proof of this in the presence of *Phyllocactus* growing in the forks of the forest trees. On the other hand, the small number of species found on the dry plains of the leeward side of the larger West Indian islands is enigmatic, unless one considers, that these islands were never intimately connected, even when a land bridge existed with the arid Mexican table-land.

The southern peninsula of Florida, which belongs in many respects as shown by many other families to the West Indian Region, has only three species of cactuses.

The fact, that we have in South America another cactaceous headquarters, does not militate against the Mexican origin of the family for between arid Mexico and arid South America there is no place where the family could thrive. Once the forms originating in arid Mexico reached arid South America, where we are compelled to consider the conditions somewhat different, we would expect to find the rapid multiplication of new forms distinct from those in the north such as *Pfeiffera* and *Cariata* in Brazil. Perhaps in the past, the Isthmian region was not as humid as at present and the Cactaceae had a better chance to spread southward. Or, that under similar conditions of environment in such widely separated localities, the progenitors of the present cactaceous forms mutated along similar lines both in arid Mexico and arid South America, so that the present distribution may be explained by the polygenetic origin of the cacti and perhaps in some instances by polyphylesis or the approach in morphologic structure of two or more different species, at different places at the same time, or at different times, so as to form a new species. Since the agricultural Indians have occupied Central America (and vast prehistoric mines, as at Copan and Palenque indicate a long occupancy) the original forest has been destroyed by fire and by other means over extensive areas and desert conditions have been established, where such plants, as *Peireskia guatemalensis* (Fig. 10), form a prominent feature of the flora.

*Yucca-Vegetation.* The phytogeographic distribution of the species of the genus *Yucca* is of interest in connection with the Mexican origin of the genus. TRELEASE[1]) believes that the Mexican table-land is the original home of the entire group and that it has followed the customary sweep around the Gulf with a reflex wave northwest into the Appalachians. Other species have entered the

1 In a letter to the writer dated Jan. 20. 1904. The northern and southern limits of the genus Yucca are indicated in the colored map. Beginning in Southern California, the northern line runs in a sinuous course across the continent to the mouth of Chesapeake Bay, while the southern line similarly extends from the head of the Bay of Lower California across Mexico to the mouth of the Rio Grande.

great Basin and still others southern California and the great plain regions of Texas, Colorado and Nebraska. The capsular Yuccas are more primitive than the baccate species, which may be looked upon as derivatives, while the spongy fruit of Cleistoyucca is a desert tumble fruit.

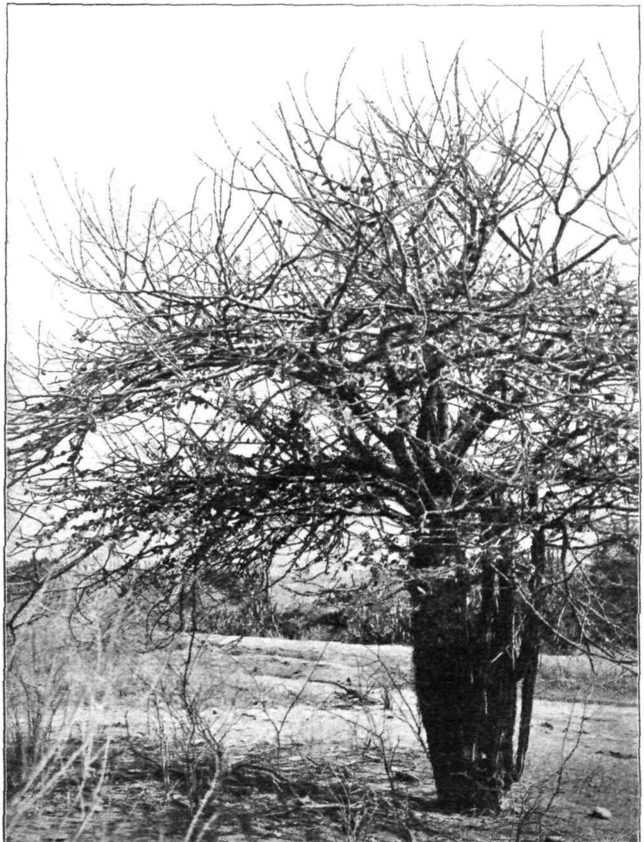

Fig. 10. *Peireskia guatemalensis* Rose in a desert near El Rancho above Zacapa, Guatemala. Photograph by O. F. Cook.

The genera *Agave* and *Dasylirion* have their headquarters in Mexico. There are recognized 140 species of *Agave* native to that country, while some are found north in Texas, Arizona and California; several in the West Indies and a number south in Honduras and Guatemala. The following list[1]) gives those occurring out of Mexico:

Agave asperrima J., Texas.
» aurea T. S. B., California.
» caribaea B., West Indies.
» dasylirioides J. & Bouche, Guatemala.
» deserti E., California.
» excelsa J., Honduras.
» geminiflora Ker-Gawl., Peru.
» hexapetala Jacq., West Indies.
» huachucensis B., Texas.
» maculata Regel, Texas.
» Margaritae T. S. B., California.
» Morrisii B., Jamaica.
Agave Newberryi E., Arizona.
» Palmeri E., Arizona.
» Parryi E., Arizona, Mexico.
» Pringlei E., California.
» Sebastiana Gr., California.
» Seemanniana J., Guatemala.
» Shawii E., California.
» sobria T. S. B., California.
» spicata Cav., Cuba.
» subinermis M. Roem., Brazil.
» virginica L., North America.
» Wallisii J., New Granada.

Besides these are found earth inhabiting Bromeliaceae, *Sedum*- and *Echeveria* species, *Mimosa*, *Cassia*, *Ephedra* and a host of other plants, which had their origin and are peculiar to the Mexican plateau.

While the vegetation of a desert type reigns supreme over the greater part of Mexico and although differing widely in the different phytogeographic regions, it may be said in general to belong to one and that a xerophytic type, there are other elements in the vegetation of the country mainly confined to the higher mountains and the lower elevations along the sea coasts that demand our attention.

## 7. Non-Desert Floral Elements of Mexico and Central America.

*Mangrove Formations of Tropics.* The mangrove formation common also to the West Indian islands extends along the entire east coast of Mexico and perhaps, as far north, as Corpus Christi in Texas. On the West coast, it extends, as far north, as the Gulf of California above Mazatlan[2]). As an element found also in the West Indies, it represents one which has probably existed along the sea coasts of the Caribbean Sea and Pacific Ocean during all the vicissitudes to which those coasts have been exposed since the evolution of the higher groups of plants to which the mangrove are phytogenetically related. There has, however, been a gradual northward extension of the mangrove vegetation, so that its present area is more extended than its past.

1) With abbreviated authors: J. = Jacobi, T. S. B. = Brandegee, B. = Baker, E. = Engelmann and others.

2) See colored map: *Rhizophora Mangle*.

*Chaparral Vegetation.* A chaparral region occupies the coastal plain in eastern Mexico above which the rain clouds sail high and it is, therefore, rather arid. This chaparral strip expands above Tampico and comprehends the valley of the lower Rio Grande River and all of that portion of southern Texas below a line which stretches from Eagle Pass on the Rio Grande through San Antonio, Texas to the coast. No fewer than forty species, according to Bray [1]), associate in this formation in many cases a limited area is tolerably uniformly covered by at least half of all the species and sometimes a single species constitutes almost the entire formation over extensive tracts. There is a distinction of species into those of semitropic and even tropic affinities and those able to endure the freezing winter temperatures ot the warm temperate zone. The prevalence of Mimoseae and Caesalpinieae in the Rio Grande chaparral deserves special mention. No less than 30 per cent of the number of species and a far higher per cent of actual individuals represent the strength of these elements in the formation. This also emphasizes the semitropic affinities of the flora and there cannot be, therefore, any doubt but what the Rio Grande chaparral represents a northern extension of the one found extending southward on the eastern coastal plain of Mexico and connecting with the scrub, or chaparral, of northern Yucatan, whore the arboreal elements belong to the Leguminosae among which are species of *Cassia*, *Acacia cornigera* and others associated with *Cereus peruvianus*, *C flagelliformis* and *Cactus opuntia* [2]).

Forty years ago, it would never have occurred to one that this arid region of the Rio Grande could ever lay claim to being in any sense a wooded country. Yet we see the spectacle of an invasion of chaparral, a horde of shrubby Mexican species pushing their vanguard into the agricultural lands of the state. A journey of the writer some few years ago across Texas confirmed the fact that of these Mexican trees the mesquite (*Prosopis juliflora*) is the dominant and strenuous species. Its spread northward and eastward by the seeds voided in the feces of cattle from the Rio Grande country during the past fifty years has been a marked phenomenon. By its invasion, mile after mile of treeless plain and prairie have been won and reduced to the characteristic orchard-like landscape. In the coast country, and likewise in the Black Prairie region, it has passed the Brazos River. It has pushed northward over the Staked plains, covering half their area. Along their eastern front, it has migrated into Kansas and Oklahoma [3]).

*Tropic Forest.* The tropic forest vegetation represents another important element in the flora of Mexico. It extends between the coastal chaparral and the arid plateau on the upper and middle slopes of the mountains which

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1 BRAY, WILLIAM L.: The ecological Relation of the Vegetation of western Texas. Botanical Gazette XXXII: 271.

2) Cf. HEILPRIN, ANGELO: Observations on the Flora of northern Yucatan. Proceedings American Philosophical Society XXIX: 137. 1891.

3) BRAY, W. L.: Forest Resources of Texas. Bureau of Forestry U. S. Department of Agriculture. Bulletin No. 47. 1904: 34.

represent the eastern rim of the Mexican table-land. Here the rainfall reaches its greatest total, for the clouds which pass over the chaparral region without depositing their moisture strike the mountains higher up and deposit their moisture in copious showers. This tropic forest may be considered as a northern extension of the forests of Tehuantepec and Central America. It sends an arm up the west coast, as far, as San Blas and gradually gives way to a semitropic forest above Tampico on the east coast, which finally loses its identity, as a semitropic forest in the northwestern part of the Mexican state of Nuevo Leon.

*Mountain Flora of Mexico.* The high mountain flora of Mexico deserves more than a passing notice. Generically the alpine flora is related to that of the Rocky Mountains, for we find in fact a large number of northern genera (*Draba*, *Viola*, *Potentilla*, *Alchemilla*, *Hieracium*, *Pedicularis*, *Juncus*, *Carex*) scattered along the mountains of Mexico and South America south to Fuegia and southern Chile where between sixty and seventy northern genera occur. Very few of the peculiarly American, or Mexican genera reach the altitudinal limit of vegetation where the plants of northern and Andine derivation are about equally balanced, thus at 13,000 feet out of 17 genera, 12 are northern, 2 endemic and 3 Andine. At 14,000 feet out of 15 genera, 11 are northern, 3 Andine and 1 endemic. Above 14,000 feet (4267 m), the few northern plants are balanced by the others and at snowline *Arenaria* and *Alchemilla* are confronted by the Andine *Chionolaena*. The number of species common to the higher cordilleras and peaks of Mexico and the Rocky mountains is extremely small. Mexico and Central America possess a great many endemic species pointing to a long separation floristically speaking of the two mountain systems and to the fact that a connection never was established between the snow deposits on the Rocky mountains and those found on the higher Mexican summits. Specifically the high mountain flora of Mexico is related to that of the Andes of South America. Consequently these mountains possess a mixed flora of northern plants; endemic ascendants from the temperate plateau base, most abundant in the middle levels and diminishing upwards; thirdly, southern plants ascendant from the tropics, and fourthly, the Andines, such as *Acaena*, *Pernettya* and *Chionolaena* [1]).

*Guatemalan Flora.* The central, or Guatemalan region [2]), which includes Guatemala, San Salvador and Honduras comprises three elements of unequal development. There is the tropic element, largely consisting of the littoral belt, which is comparatively unimportant. The xerophilous element of the dry regions of the plateau, which may be considered to be an extension of the characteristic flora of North Mexico. This element is the dominant one in many districts of Guatemala which were formerly covered with dense forests before the occupation of the country by the agricultural Indians. COOK states that in all denuded areas on the desert plains and in regions now covered with forest,

1) GADOW, HANS: Altitude and Distribution of Plants in southern Mexico. Journal of the Linnean Society, Botany XXXVIII: 429—440.

2) HEMSLEY, l. c., see p. 83, Bibliography.

there are indications of prehistoric agriculture and human occupation, so that the entire vegetation has been altered by fire used to clear the land of the continuous forest growth. — Finally, there is the distinct preponderating element which furnishes the prominent features of the whole flora. Setting aside those plants characteristic of a dry climate, we find evidence of an enormous development in certain groups of plants which flourish only where there is considerable humidity. These are the plants that inhabit the eastern slopes and ravines, and constitute what we should call the special flora of this province in contra-distinction to the southward extensions of north-Mexican flora. COOK among other interesting observations states that in Guatemala after the fire-swept areas have been cultivated and then abandoned to grass land, the process of reforestation may betraced through a succession of temporary types, such as pines, oaks, and other tropic trees, such as *Acrocomia*, *Cecropia* and *Attalea* [1]. Yet here northern and southern types meet and commingle in a most remarkable manner; and the endemic element is specific, rather than generic. The diversified oak-forests laden with epiphytic orchids, bromeliads and other plants equally characteristic of the vegetation south of the Isthmus of Panama afford the best illustration of the correctness of this statement. It is true the oak type is not peculiarly characteristic of a moist climate, but it is essentially northern, and although, it has reached the Andes of South America, its development there is quite insignificant. On the other hand, the orchids associated with the oaks of Mexico belong almost wholly to genera equally, or more strongly represented in South America. Thus only nine out of upwards of a hundred genera are endemic in our central region; and only fourteen are restricted to the country north of the Isthmus of Panama. Further, ten of the fourteen genera are monotypes, and the others number very few species; moreover, it is noteworthy that nearly as many genera reach eastern, as western South America.

The flora of Guatemala is essentially of the same composition as that of South Mexico, though apparently less rich in specific diversity. Of the eastern North American deciduous arboreous types in South Mexico, just alluded to, some as *Tilia* and *Ulmus* are not known to reach Guatemala, while others such as *Liquidambar*, *Morus*, *Ostrya* and *Carpinus* are present, and the two latter have here their southern limit. As might be expected, too, some characteristic South American types find their northern limit in Guatemala. Noteworthy among these are the Vochysiaceae; the genera *Vochysia* and *Trigonia*, being both represented.

*South American Element.* The southern floral province, comprising Nicaragua, Costa Rica and Panama exhibits much closer relationship with the South American tropic flora, and may be of more recent derivation, but the large number of South American types which reach Mexico or Guatemala, and not the West Indies, indicate a more remote connection though of course it may not have

1) COOK, O. F.: Vegetation affected by Agriculture in Central America. Bull. 145. Bureau Plant Industry.

been continuous. The composition of the flora of Costa Rica [1] and Panama, so far as investigated is decidedly South American. Taking some of the mainly tropic orders, such as Dilleniaceae and Anonaceae, we note a gradual thinning out northward, and an extension into the southern province of many South American species. The essentially eastern South American Lecythideae is represented by four genera and seven species, one of which is common in Nicaragua, the northern limit of these trees. *Podocarpus* replaces *Pinus* in the mountains of Costa Rica extending to Cuba in two species: *P. angustifolia*, *P. aristulata*, and to Jamaica in *P. Urbanii* and *P. Furdicana* (see colored map), and the Cylanthaceae are relatively numerous in the lower regions. Noteworthy examples of southern limits of northern types are offered by *Liquidambar*, *Sabiaceae* and *Juglandaceae* in Costa Rica, and *Pinus* in northern Nicaragua. The oak-vegetation of Volcan de Chiriqui comprises at least three species; and *Arbutus* and *Arctostaphylos* give way to South American genera of the Vacciniaceae in the mountains generally. *Chamaedorea*, the characteristic genus of palms in the oak forests of south Mexico, is represented in the southern province by at least half a dozen species, but the majority of palms belong to genera having their greatest development south of Panama, as is excellently exemplified by the genus *Attalea* (Honduras-palm, *Attalea Cohune*, Plate V), which is found through the whole of Brazil extending, as far, as Guiana and Colombia, and next to *Cocos* is a prevailing genus of brazilian palms. Many other examples of a change in the vegetation nearly coincident with the northern boundary of Nicaragua might be given.

Nearly, if not quite, all of the genera of the mountain flora there recorded from 8000 feet and upwards in our southern province are such as range from Mexico to the Andes of South America and some of them farther. The alpine forms of the Andes of South America belong for the greater part to the same genera which inhabit the higher regions of the mountains of Central America and Mexico, though the species are rarely identical. There seems to have been an northward extension of temperate and alpine forms, as well, as tropic, and such genera as *Drimys*, *Fuchsia*, *Colobanthus*, *Calceolaria*, *Roupala*, etc. are perhaps of southern origin. It follows that northern Mexico is the focus of a xerophilous flora extending into the dry regions of South Mexico, and into territories north of Mexico. The central province, disregarding the purely tropic and the xerophilous overlappings, is a mingling of northern and southern types which exhibit an extraordinarily rich production of local species, associated with about 12 per cent of indigenous genera [2]. The southern region is an outlying portion of the American tropic flora, and in composition is almost limited to specific differentiations. The tropic element in this region is more closely allied to that of eastern South America, even

1) POLAKOWSKY, H.: Die Pflanzenwelt von Costa Rica. XVI. Jahresbericht des Vereins für Erdkunde zu Dresden. 1879: 25—124.

2) HEMSLEY, l. c.

**Attalea Cohune** Mart.

Cohune Palm, growing at San Pedro, Honduras.

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than it is to that of the West Indies, and includes types of the former, which are not known to reach the West Indies.

The facts here considered relative to the composition and the distribution of the flora of Central America and Mexico demonstrate that, apart from the peculiar Mexican element and the southward extensions of northern types, there are two other distinct elements, namely, the tropic and the Andine.

The relationship existing between the past and present distribution of species in Mexico, Central America and the West Indies, as controlled by the geologic and physiologic changes accompanying elevation and subsidence, and the change of climate, as well, as the relative distribution of the land and water areas is here briefly set forth. It should be stated that a separate description of the various West Indian elements has been purposely omitted from the foregoing discussion because of ignorance, but will now be referred to in the following description of the factors underlying and determining the distribution of plants in Mexico, Central America and the islands forming the Greater Antilles.

According to the evidence that we have, the evolution of new forms was most rapid in Mexico, for from the facts we must believe, that the cacti, agaves and yuccas originated there. The period at which this development took place must have been subsequent to the upper Cretaceous period for the greater part of Mexico except a narrow strip along the west coast was under the ocean during the lower Cretaceous. During the upper Cretaceous period, Mexico was elevated above the sea and during the lower Tertiary was connected with the West Indian islands. During the upper Tertiary, the West Indian bridge was severed and the North American continent reached its present shape. It was during the Tertiary, that the physiographic and geologic changes were taking place in Mexico when the valleys were filled to their brim by erosion and volcanic discharges, recorded in an earlier part of this work. We have, therefore, no reason to doubt that during these physiographic upheavals, that mutation was active in the development of new species and that many of the forms of vegetal life peculiar to the Mexican plateau then had their rise as new forms. Let us briefly trace the history of the vegetation of North America as illuminated by the discussion of the facts presented above.

If ORTMANN's [1] views as to the distribution of the land and water decapods are correct, many tropic forms came into Mexico during the upper Cretaceous when Mexico was connected with South America and the West Indies by a land bridge which was severed in early Tertiary times. But the writer believes, that the tropic element of the continental flora was of later derivation than this, although many forms no doubt migrated northward during the upper Cretaceous period.

*Origin of the Antillean Flora.* The West Indies and Central America constitute an evolutionary region of their own distinct from the North American

1) ORTMANN, Dr. A. E.: The geographical Distribution of freshwater Decapods bearing upon ancient Geography. Proceedings American Philosophical Society XLI: 267. April—December 1902.

continent of past geologic times. Central America, the West Indies and northern South America formed in the Mesozoic period (certainly during the Jurassic and Cretaceous), a continental mass (Antillean continent) which was bounded by sea to the north and south [1]). This continent broke up at the end of the Cretaceous, the chief factor in its destruction being the formation of the Caribbean Sea, which connected with the Pacific Ocean during the lower Tertiary period across the submerged Isthmus of Panama. The northern remnant of this continent, consisting of the Greater Antilles and parts of present Central America probably remained a unit up to the Eocene, for during the Eocene elevation there was probably a landway from Cuba across the Bahama Banks to the Floridan area, so that we have an explanation of the exceptional association of *Pinus cubensis* and *Serenoa serrulata* (see Plate VI) in southern Florida, although it is well known that the northern coniferae stop where the tropic-subtropic palms begin to occur. At the end of the Eocene, and during the Oligocene and Miocene, the connection between the Greater Antilles and the mainland was severed. But it was re-established toward the end of the Tertiary for before the close of the Tertiary period, the West Indian lands were more extensive than now, and the Greater Antilles were once continuous. The botanic evidence goes to show that there existed in the past (upper Cretaceous), an Antillean continental flora which developed as such when the West Indian islands, Central America and northern South America formed a distinct continental area with rivers, mountains and plains covered with a tropic forest of great luxuriance which represents the progenitors of the present tropic flora. The table by HEMSLEY unquestionably points to such a conclusion.

Proportional Distribution of Mexican and Central American Species in South America and the West Indies [2]).

| | | Common to both the West Indies and South America | West Indies only | Western South America only (including Andine) | Eastern South America included Venezuela only | Western and Eastern South America only | Numbers of South American types reaching Mexico or Guatemala, but not the West Indies |
|---|---|---|---|---|---|---|---|
| Polypetalae | Dicotyledoneae | 190 | 55 | 143 | 66 | 212 | 265 |
| Gamopetalae | Dicotyledoneae | 182 | 112 | 129 | 65 | 80 | 177 |
| Incompletae | Dicotyledoneae | 97 | 43 | 36 | 30 | 34 | 72 |
| Monocotyledoneae . | | 179 | 71 | 64 | 99 | 103 | 183 |
| Gymnospermae . . . | | — | 3 | 2 | 1 | — | 1 |
| Totals | | 648 | 284 | 374 | 261 | 429 | 698 |

This table is only tentative, because so much remains to be done in elaborating the details of the distribution of species in the West Indies and the northern and eastern parts of South America. The western only are in

1) See ante page 120.

2) HEMSLEY, BOTTING: Biologia Centrali-Americana IV: 227. 1886—1888.

**Serenoa serrulata** (Michx) Hook (saw palmetto)
associated with Pinus cubensis Griseb. (= P. heterophylla = P. bahamensis = P. Elliottii = P. caribaea, slash pine) to form pine barrens of Southern Florida.
Reproduced by permission of the Philadelphia Museum.

considerable excess of the eastern only. The most striking feature in the table is the large number of species common to South America, but not known to inhabit the West Indies.

The distribution of the following species of the following genera, selected at random, it seems represent part of the tropic flora which may be called Antillean, because the plants enumerated in their present distribution occupy the edge of the Caribbean basin which geologists tell us has been formed by the depression to great depths of a former land surface. North South America represents the southern rim of this basin, Central America the western edge with the Galapagos islands, perhaps an outlying extension of this ancient continent into the Pacific ocean, and the greater Antillean chain of islands representing the northern limit of this Caribbean landmass. The species now mentioned represent, but a small number of those plants which have a similar range about the shoreline of the Caribbean Sea, viz.

Cassia alata L. Nicaragua, Panama, West Indies and tropic America.
- » atomaria L. South Mexico, Central America, Colombia to Peru.
- » bacillaris L. South Mexico, Yucatan, Tabasco, Nicaragua, Costa Rica, northern part of South America, West Indies.
- » bicapsularis L. North Mexico, South Mexico, Yucatan, Tabasco, Guatemala, Costa Rica, southward to South Brazil and Chili.
- » biflora L. South Mexico, Guatemala, Nicaragua, Costa Rica, West Indies and northern part of South America.
- » chamaecrista L. Canada to Mexico, Guatemala and southward to Uruguay.
- » diphylla L. South Mexico, Guatemala, Nicaragua, Panama, West Indies and tropic South America.
- » grandis L. Panama, West Indies, Colombia, Guiana and Brazil.
- » riparia H. B. K. Central America, West Indies, Guiana, North Brazil.
- » sericea Sw. Texas, North Mexico, South Mexico, Central America, West Indies and North Brazil.
- » spectabilis DC. South Mexico, Costa Rica, West Indies, northern part of South America.
- » tagera L. South Mexico, Costa Rica, Panama, north part of South America.
- » virgata Sw. Guatemala, Colombia, Guiana and the West Indies.

Cuphea balsamona Ch. & Schl. South Mexico, Nicaragua, Guatemala, Panama, southward to Uruguay and in the Galapagos islands.
- » spicata Cav. South Mexico, West Indies, South America to Uruguay and Chili.

Passiflora adenopoda DC. South Mexico, Venezuela, Panama, Colombia.
- » coriacea Juss. South Mexico, Panama, Jamaica, Colombia, Peru.
- » lunata Willd. South Mexico, Costa Rica, Panama.
- » var. costata Mast. Jamaica, Venezuela, Colombia.
- » sexflora Juss. South Mexico, West Indies.
- » suberosa L. var. minima Mast. Mexico, West Indies, Central America.
- » tuberosa Jacq. South Mexico, West Indies, Guiana.

Sechium edule Sw. South Mexico, Panama, West Indies, tropic South America.
Ipomoea acuminata Roem. & Schult. Guatemala, West Indies to Brazil.
» capillacea Don. (I. armata Roem. & Schult.). Arizona, New Mexico, North Mexico, South Mexico, Guatemala, Colombia, Venezuela.
cathartica Poir. Florida, Mexico, Bahamas, Jamaica, St. Vincent, Brazil.
hederacea Jacq. Pennsylvania to Florida, Louisiana, Mexico, Central America, tropic America, West Indies.
longicuspis Meissn. (I. bicolor Lam.) Mexico, West Indies, to Peru and Brazil.
purpurea Roth. Texas to California, Mexico, Colombia, Venezuela, West Indies.
quinquefolia L. Guatemala, Nicaragua, Panama, southward to Peru and Bolivia, West Indies.
setifera Poir. Guatemala, Nicaragua, Panama, West Indies, Guiana to North Brazil.
sidaefolia Choisy. South Mexico, Panama, West Indies, north part of South America.
sinuata Ort. Georgia to Texas, North Mexico, South Mexico, Guatemala, West Indies, Guiana, Brazil.
umbellata Mey. South Mexico, Guatemala, Nicaragua, tropic south America, West Indies.
Escobedia scabrifolia Ruiz et Pav. South Mexico, Colombia, to Peru, Guiana, Brazil.
Lippia americana L. Panama, Colombia, Ecuador.
» geminata H. B. K. Texas, North Mexico, South Mexico, Nicaragua, Costa Rica, Panama, South America, West Indies.
» reptans H. B. K. South Mexico, West Indies to Brazil and Peru.
Stachytarpheta cajanensis Vahl. South Mexico, West Indies southward to Brazil.
» jamaicensis Vahl (S. indica Vahl). Florida, Mexico, Central America, West Indies, south to Brazil.
» mutabilis Vahl. Mexico, Cuba, Trinidad, Guiana.

*Tropic American Element.* The origin of the tropic American flora is to be looked for in the lost Antillean continent, northern and eastern South America. Certainly many Brazilian species occur in Central America and the West Indies and BALL [1]) says that in a general survey of the South American flora in addition to the elements derived from distant regions there is a large number of types either absolutely peculiar to the continent, or which, in some cases appear to have spread from that center to other areas. According to him the tropic forms had their primitive home in Brazil, and it is precisely on the ancient mountains of this region, which perhaps formed one of the greatest mountain regions of the earth, their summits exceeding in a height any now existing in the world, and worn down by erosion in a region of heavy

1) BALL, JOHN: Notes of a Naturalist in South America. London 1887: 313—319.

rainfall, that we should look for the ancestors of many forms of vegetation which have stamped their character on the vegetation of the continent. In addition, the mountains of Venezuela and Guiana, representing the southern part of the Antillean land extension may be considered also as a center from which the tropic flora has spread. This region during lower and upper Cretaceous periods was severed from eastern Brazil and during that time an endemic tropic flora was in process of development. This flora is characterized by the great richness in Araceae and Orchidaceae. While separated from the south and also with several distinct orographic systems small areas existed which developed peculiar endemic forms for which this region is noted. No part of America has been more frequently visited by European plant importers in search of aroids, palms, orchids and bromeliads than this.

Later northern South America was connected with eastern Brazil and it was then that the plants mentioned by BALL migrated north to Guiana, where they form an important element, and subsequently into Central America and the West Indies. The tropic element of the North American flora represents three distinct elements of development, viz., the subandine region, which according to ENGLER furnished a large contingent of species, the Antillean continent including Venezuela and the eastern Brazilian district, which subsequent to the Cretaceous period furnished a considerable number of migrant forms which found their way northward, while the higher Andes contributed many types to the higher Mexican mountains. We are not in a position to clearly separate from each other the plants derived from all these areas, but we have proceeded far enough to discover that the Mexican, Central American, West Indian and Brazilian tropic floras are all connected by identic species of plants. If diversity has occurred, it has been through the isolation of areas of great physiographic difference permitting the differentiation of new types of plant life from old forms. This separation of land masses into groups by the encroachment of the sea has also separated widely distributed forms which remain as relicts in circumscribed areas, or it has led to the extinction of many forms once widely prevalent.

*West Indian Flora.* GRISEBACH [1]) early compared statistically the flora of the different West Indian islands under English control and the facts discovered by him bear out the statement just made, that although, the Central American, northern South American and West Indian floras are genetically related historically, yet sufficient time has elapsed since the disruption of the Antillean continent to bring about a rich endemism in the several regions. Our knowledge of the West Indian flora has vastly increased since 1864, but we still lack sufficient data on which to make a satisfactory and complete statistic comparison of this flora with others adjacent to it. We have brought out some of the salient features in a preceding chapter. It only remains to say in this connection, that the table in GRISEBACH's great work is helpful in

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1) GRISEBACH: Geographische Verbreitung der Pflanzen Westindiens.

elucidating the fact that there is a greater endemism in each of the Greater Antillean islands than in those of the Lesser Antilles, for the simple reason that the large islands are continental in aspect, have sedimentary rocks and represent part of the original Antillean landmass, which was covered by an Antillean flora of great richness, while the islands of the Lesser Antilles are volcanic and of comparatively recent creation, representing a line of weakness of the earth's crust through which volcanic material has been extruded along the eastern edge of the lost Atlantis (Antillean continent), when it sank out of sight with the formation of the American Mediterranean, the Caribbean Sea. The flora of these islands, therefore, is a recently derived one and represents one that has not had sufficient time for the differentiation of new endemic types, hence the discrepancy in the number of endemic types in the two groups of islands which the table of GRISEBACH sets forth. Presumably the appearance of the Caribbean Sea by the depression or sinking down of the former land surfaces of the Antillean continent to great depths below the surface separated the Antillean flora into three parts, viz., the West Indian, the Central American and the northern South American. The West Indian flora was at one time perhaps remarkably uniform for during the close of the Tertiary period, we have evidences that the West Indian land areas were much more extensive than now, and the greater Antilles were once continuous. With the depression of the islands in subsequent periods, the West Indian landmass was broken up into physiographically distinct regions and the present differentiation of the flora began at this time. So that for the several larger islands of the Greater Antilles, we have a diversification of the flora which has been statistically stated in a foregoing chapter of this book.

The Bahamas are very recent geologically speaking and their elevation above the sea has been placed not earlier than the late Tertiary, so that excellent opportunities are afforded in this group to study plant migration and evolution. The flora has been remarked in a former page is of southern derivation, a large number of the known indigenous species being common to the nearby and older islands of Cuba and Haiti, while many other species are closely related to plants from these islands. The chief agents in the introduction and distribution of the plant population are according to BRITTON [1]) migratory birds, supplemented by winds and ocean currents. Notwithstanding the geologically short period that the Bahama islands have been above the sea, they have witnessed the evolution by mutation, or otherwise, of numerous species, there being many endemic species known and many more which will be made known as the result of recent explorations. We have then to deal before the glacial period with seven distinct regions with types of vegetation developed during the Cretaceous and Tertiary periods in situ, and which to some extent migrated from area to area, as the relative position of the land

1) BRITTON, N. L.: A botanical Cruise in the Bahamas. Science new ser. XXI: 628. April 21, 1905.

and waters were altered. These seven types are: the circumpolar arctic flora, the north temperate continental forest flora, the Pacific forest vegetation, the grass land vegetation, the Mexican highland flora, the South American and Antillean continental tropic floras. It was by the combination and recombination of these several types of vegetation, the sorting and geographic re-arrangement of species in geologic periods subsequent to the Cretaceous period, especially during the glacial period, that the distribution of the plants of the present North American flora is directly traceable.

## Chapter IV. **Affinities of North American Flora.**

### 1. Arctic America.

In considering the affinities of the flora of arctic North America, it is necessary to present a few facts and statistics about the arctic flora of the world in general. The arctic flora occupies a circumpolar area north of the arctic circle. There is no abrupt break in the vegetation anywhere along this belt, except at Baffin Bay, where a sudden change from an almost purely European flora in Greenland on its east coast, to one with a large admixture of American plants on its west. Regarded as a whole, the arctic flora is decidedly Scandinavian, for arctic Scandinavia, or Lapland, though a very small tract of land, contains by far the richest arctic flora, amounting to three fourths of the whole; more over, according to HOOKER, upwards of three-fifths of the species, and almost all of the genera of arctic Asia and America are likewise Lapponian, leaving far too small a percentage of other forms to admit of the arctic Asiatic and American floras being ranked as anything more than subdivisions of one general arctic flora. The American district, omitting Greenland, is separable into two districts, the eastern American and the western American, separated from each other by the estuary of the Mackenzie River.

*The North-American districts.* Arctic western America extends from Cape Prince of Wales on the east shore of Bering Strait to the estuary of the Mackenzie River, and as a whole, it differs from the flora of the district to the east by the far greater number of both of European and Asiatic species by containing various Altaic and Siberian plants, which do not reach so high a latitude in more western meridians and by some temperate plants peculiar to western America. The number of phanerogamic plants found in arctic western America is approximately 364 species. Of these 364 species almost all but the littoral and purely arctic species are found in west temperate North America, or in the Rocky Mountains, 26 in the Andes of the tropic, or subtropic America and 37 in temperate or antarctic South America. Comparing this flora with that of temperate and arctic Asia, no less than 320 species are found on the north-western shores and islands of that continent, or in Siberia, many extending to the Altai and Himalaya Mountains. A comparison with

eastern arctic America shows that 281 are common to it, and that 38 are found in temperate, but not arctic eastern America [1].

The flora of arctic east America differs from that of the western part of the continent, in possessing more east American species. The western boundary is an artificial one, but the eastern is natural both botanically and geographically, for Baffin Bay and Davis Strait have very deep water and different floras on their opposite shores. The portion of this province richest in plants is the tract between the Coppermine and Mackenzie rivers. East of this the number of plants rapidly diminishes and also to the northward. The flora of arctic east America consists according to HOOKER of 379 species. Of these 379 species, 323 inhabit temperate North America, east of the Rocky mountains; 35, the Cordilleras; and 49, temperate antarctic South America. Comparing this flora with that of Europe, it is found that 239 species are common to the arctic regions of both continents, while but little more than one third of the arctic European species are arctic east American. Of 105 non-European species in arctic east America, 32 are Asiatic; leaving 73 species confined to America.

Douglasia arctica and Pleuropogon Sabinii are the only plants absolutely peculiar to arctic east America. Compared with Greenland, the flora of arctic east America is rich including many species not found in Greenland. The following are found on the arctic islands, and many of them on the west coast of Baffin Bay, but not in west Greenland.

Caltha palustris L.
Parrya arctica R. Br.
Arenaria (Merkia) physodes Fisch.
Stellaria crassifolia Ehrh.
Astragalus alpinus L.
Oxytropis campestris D.C.
» uralensis D.C.
» nigrescens Fisch.
Geum (Sieversia) Rossii Ser.
Saxifraga hieracifolia Waldst. & Kit.
» virginiensis Mich.
Valeriana capitata Pall.
Nardosmia corymbosa (= Petasites frigidus Fries) Hook.
Chrysanthemum arcticum L.
Artemisia vulgaris L.
Salix phlebophylla Anderss.
Lloydia serotina Sweet (= L. alpina Salisb.).
Glyceria fluitans R. Br.
Bromus purgans L. (= B. ciliatus L.)
Senecio frigidus Less.
» palustris Hook.
» pulchellus D.C.
Solidago virga-aurea L.
Aster salsuginosus Hook. (= A. peregrinus Pursh).
Crepis nana Richards.
Saussurea alpina D.C.
Andromeda polifolia L.
Arctostaphylos alpina Spreng.
Kalmia glauca Ait.
Phlox sibirica L.
Castilleja pallida Kunth.
Pedicularis capitata Adams.
» versicolor Wahlenb. (= P. Oederi Vahl).
Androsace septentrionalis L.
» Chamaejasme Willd.
Hierochloe pauciflora R. Br.
Pleuropogon Sabinii R. Br.
Elymus mollis Trin.

1) HOOKER, J. D.: Outlines of the Distribution of arctic Plants. Transaction Linnean Society of London XXIII: 251—348. 1860.

No fewer than 184 of the 379 arctic east American species (fully half) are absent in west Greenland, whilst only 105 (much less than one-third) are absent in Europe. Of the 379 arctic east American species only 56 are not found in temperate east America, of which two are absolutely confined to this area; two others, *Parrya arenicola* and *Festuca Richardsoni*, to arctic east and west America; 25 are found in temperate west America, and about 20 are Rocky Mountain species, and not found elsewhere in temperate America.

*Algae*. The strong endemism of the purely arctic marine flora points to it as no immigrant flora, but one that possesses its center of development in the Arctic Sea. Other circumstances lead cogently to the same conclusion, indicating at the same time that the present purely glacial marine flora must have been formerly more widely spread towards the south than it is now. This results from a comparison of the flora of the Arctic Sea with that of the northern Atlantic and the northern Pacific. The Arctic Sea possesses 184 species in common with the North Atlantic and only 11 of these species are exclusively American, for by far the greater number occur on the Atlantic coasts of Europe according to KJELLMAN[1]). The present flora in the northern part of the Pacific differs so essentially in composition from that of the northern Atlantic, that is to say, it contains many species that are so sharply distinguished from those of the Atlantic, even belonging to quite different types, that in order to account in any way for this fact, one is necessarily obliged to assume that these two divisions of the ocean appertain to different areas of development within which different forms have continued to be evolved during a very long time. (Confer Phyllospadix: Fig. 11, p. 314.) However, on the other hand, it is a well known fact that the northern Atlantic has no inconsiderable number of species in common with the northern Pacific.

*Comparison of North Temperate and Arctic Liverworts*. In the north temperate and arctic zones, according to UNDERWOOD[2]) (1892), there are known about 575 species of liverworts, Musci hepaticae. Of these 375 belong to the flora of Europe, 300 to that of America, and perhaps 150 to that of Asia. Of these, we may take, as representing the boreal and sub-boreal portions, 173 species for northern Europe, 163 for northern America, and 98 species for northern Asia. Of the 214 boreal and sub-boreal species, eighty per cent are European, seventy-six per cent are American, and forty-six per cent are Asiatic. While the larger part of the species of Europe and America have been brought to light, it is quite likely that the smaller number known from the more extensive Asiatic continent is due to the limited exploration of that region. Of the 163 American species, 129 or seventy-eight per cent are of the European flora; 69 are also Asiatic, while 32, or twenty per cent, are endemic.

1) KJELLMAN, F. R.: The Algae of the Arctic Sea. 50. 1883.

2) UNDERWOOD, LUCIEN M.: A preliminary Comparison of the hepatic Flora of boreal and sub-boreal Regions, Botanical Gazette XVII: 305. October 1892.

Fig. 11. *Phyllospadix Scouleri* J. W. Hook., a marine plant of the family Potamogetonaceae ranging from Vancouver Island to Santa Barbara, California. After Die Natürlichen Pflanzenfamilien II 1, p. 205.

## 2. Plants common to Europe and northeast America.

The species of plants which are common to Europe and northeast United States can be divided into four classes. First, the strictly alpine species, all having a north or northwestward range found mostly on the highest summits of the White Mountains, the Adirondacks and in other elevated situations, may be enumerated as follows:

Cardamine bellidifolia L.
Viola palustris L.
Silene acaulis L.
Sibbaldia procumbens L. (= Potentilla Sibbaldii Hall. f.).
Potentilla frigida Vill.
Saxifraga rivularis L.
» stellaris L. var. comosa Poir.
Epilobium alpinum L.
Epilobium alpinum L. var. majus Wahl. (= E. origanifolium Lam.).
Gnaphalium supinum L.
Vaccinium uliginosum L.
Arctostaphylos alpina Spreng.
Cassiope hypnoides D. Don.
Bryanthus taxifolius A. Gray.
Rhododendron lapponicum Wahlenb.
Loiseleuria procumbens Desv.
Veronica alpina L.
Castilleja pallida Kunth.
Euphrasia officinalis L.
Diapensia lapponica L.[1]
Polygonum viviparum L.
Oxyria digyna L.
Empetrum nigrum L.
Salix herbacea L.
Luzula arcuata Sw.
» spicata DC.
Juncus trifidus L.
Scirpus caespitosus L.
Carex scirpoides Michx.
» capitata L.
» canescens L.
» caespitosa L.
» atrata L.
Phleum alpinum L.
Agrostis canina L.
Poa laxa Haenke.
Festuca ovina L.
Triticum violaceum Hornem. (= Agropyron violaceum Vasey).
Aira atropurpurea Wahlenb.
Hierochloe alpina Roem. & Schult.

The forty species comprise all those found in the alpine region of the northeastern states, and there are but nine species found here, which are not also found in Europe. These are as follows:

Arenaria groenlandica Spreng.
Geum radiatum var. Peckii (= G. macrophyllum Pursh).
Solidago thyrsoidea E. Mey.
Arnica Chamissonis Less. (= A. mollis Hook.).
Prenanthes (Nabalus) nanus DC.
» (Nabalus) Boottii D. Dietr.
Vaccinium caespitosum Michx.
Salix Cutleri Tuckerm.
Calamagrostis Pickeringii A. Gray.

1) See plate II, p. 188. — *Cornus canadensis* is nearly allied to the European species *Cornus suecica* L.

The following plants, not found north of 48° in America, are not met with north of 55° in Europe:

Myriophyllum verticillatum L.
Zannichellia palustris L.
Vallisneria spiralis L. (Europe: 46° n. l.).
Typha augustifolia L.
Najas major All.
Najas flexilis Delile.
Ruppia maritima L.
Potamogeton compressus L.
» obtusifolius Mert. & Koch.
Carex riparia Curt.

The following ten species are all found in this country at least, as far north, as latitude 50° and few of them extend north of latitude 55° in Europe[1]).

Sagina procumbens Hook.
Circaea lutetiana L. (Norvegia: 61° n. l.)
Scrophularia nodosa L. (Norvegia: 70° n. l.)
Salsola Kali L.
Lythrum hyssopifolium M. A. Curt. (= L. alatum Pursh).
Centunculus minimus L.
Rumex maritimus L.
Carex muricata L. (Norvegia: 64° n. l.)
» laevigata Sm.
Hordeum pratense Huds. (= H. secalinum Schreb.).

## 3. Eastern North America and Eastern Asia.

Since ASA GRAY by a comparison of the elements of the flora of North America with those of other regions established the fact that the flora of eastern America is related to that of eastern Asia, his conclusions have been accepted as expressing a phytogeographic principle of wide application. This comparison[2]) will bring out the salient features of our flora. If we compare the United States with Japan, Manchuria and northern China, i. e. eastern North America with eastern north Asia we find an astonishing similarity. The larger part of the genera of the eastern region which are wanting in California are present in Japan, or Manchuria, along with other peculiar plants divided between the two. There are plants of the one region which have no representatives in the other. There are types which appear to have reached the Atlantic states from the south; and there is a larger infusion of subtropic Asiatic types into temperate China and Japan; in the case of these there is no relationship between the two countries. There is also, no small number of genera with some species which, being common all around or partly around the northern temperate zone, have no special significance because of their occurrence in these two antipodal floras. The point to be made is, that many, or even most, of the genera and species which are peculiar to Atlantic North America, as compared with Europe, and largely peculiar to Atlantic North America, as compared with the Californian region, are also represented in Japan and Manchuria, either by identic or closely similar forms. The same rule holds

1) JAMES, JOSEPH F.: On the geographical Distribution of the indigenous Plants of Europe and the northeast United States. Journal Cincinnati Society Natural History April 1887.

2) GRAY, ASA: Presidential Address: Proceedings American Association for Advancement of Science. XXI: 1—31.

on a more northward line, although not so strikingly. If we compare the plants, say of New England and Pennsylvania with those of Oregon, and then with those of northeastern Asia, we shall find many of our own repeated in the latter, while only a small number of them can be traced along the route even so far as the western slope of the Rocky Mountains. And these repetitions of east American types in Japan and neighboring districts are in all degrees of likeness. Sometimes, the one is indistinguishable from the other; sometimes, there is a difference of aspect, but hardly of tangible character; sometimes, the two would be termed marked varieties if they grew naturally in the same forest, or in the same region; sometimes, they are representative species, the one answering closely to the other, but with some differences regarded as specific; sometimes, the two are merely of the same genus, or not quite that, but of a single, or a very few species in each country. In the paper above cited by ASA GRAY and also in the classic work of A. ENGLER, 1879 (see Bibliography page 47, vol. I. 22—43) a comparison is made by means of tables of the floras of three widely separated regions, Atlantic North America, Pacific United States and north eastern Asia, Japan to Altai and Himalayas. Alpine plants on the one hand, and subtropic plants on the other, are excluded, as also species which extend through Europe into north-eastern Asia, the object being to exhibit the peculiar relations of the floras of eastern North America and eastern temperate Asia. Only seven genera are peculiar to north-eastern Asia and north-western America: viz., *Phellopterus (Glehnia)*, *Fatsia (Oplopanax)* and *Lysichitum*, each of a single species common to both coasts; *Achlys*, of which there is a Japanese species said to differ from the American; *Boschniakia*, of a common high northern species, and a peculiar one to California; *Echenais (Cnicus)* of one or two Asiatic species, one of them lately found in California and Colorado, but possibly of recent introduction; and *Castanopsis*, a rather large and characteristic east Asian genus, represented by a single, but very distinct, species in Oregon and California.

## 4. Tropic and Subtropic Affinities.

In addition to the European element and the element which shows relationship to the flora of eastern Asia, the flora of eastern North America has a very strong admixture of species which belong to the tropic and subtropic countries. Growing amid the very large body of Carolinian forms which characterize the lower slopes of the mountains and the valleys between there occurs a much smaller number of species which are most abundant in and characteristic of the austro-riparian area of the lower Austral climatic zone of some phytogeographers. Only two or three trees and a few shrubs, which are distinctly of the lower Austral zone, extend into the mountain region[1]. There is, however, a respectable number of herbs, a hundred species and over, which, most

1) KEARNEY, THOMAS H.: The lower austral Element in the Flora of the southern Appalachian Region. Science new ser. XII: 830—842. Nov. 30, 1900.

abundant and widely distributed in the austroriparian area, are known to occur on the mountains at an elevation of 300 meters (1000 feet), or more. A faint indication of this southern element is perceptible as far north, as West Virginia, and southeastern Kentucky; while on the isolated granitic outcrops in northern central Georgia and northern Alabama, of which Stone Mountain is the type, it is so extensive as somewhat to obscure the main element of the flora round

Fig. 12. *Sassafras officinale* Nees, an element of the deciduous forest formation of eastern North America from Maine to the Gulf of Mexico. After Die Natürlichen Pflanzenfamilien III 2, p. 118.

about. Confining our attention to the mountains of Tennessee and North Carolina above an elevation of 300 meters (1000 feet), we proceed to trace the peculiarities of the flora and its affinity to the other floras.

The presence at this elevation of a considerable number of austro-riparian species, which nowhere venture beyond the limits of their life zone, is on the whole the most noteworthy fact in regard to this element in the highland flora of the southern states. In studying this floral element, one soon reaches the conclusion that it comprises two categories of species, which are different

not only in their systematic relationships, present distribution in the region and probable past history, but even, to a considerable degree in their ecologic constitution.

The first category includes plants of probable neotropic origin which have in all likelihood made their first appearance in the Appalachian region in geologically very modern times, probably after the close of the glacial period. The second category includes plants probably not of neotropic origin which are in several cases, probably the more or less modified descendants of the flora of later Eocene and Miocene times that extended to high

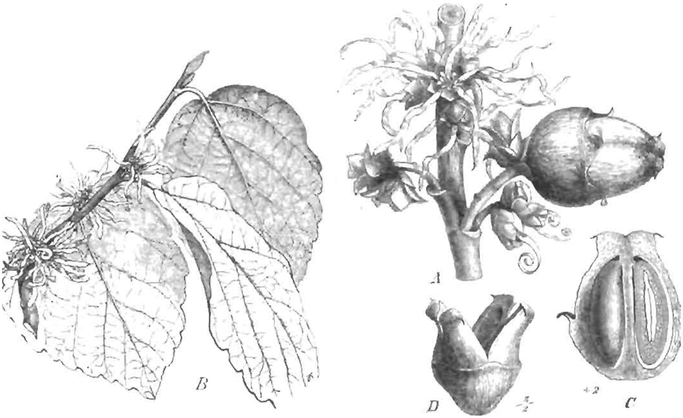


Fig. 13. *Hamamelis virginiana* L., witch hagel. An element of the deciduous forest formation of eastern North America from Nova Scotia to Texas, producing its flowers in early winter. After Die Natürlichen Pflanzenfamilien *III* 2a, p. 128—129.

northern latitudes. The number of plants in this group occurring both in the coastal plain and in the Appalachian region is notably smaller than in the first group. Most of the species, as well, as many of the genera, comprised in this category are characteristic neither of tropic, or high northern regions. They belong in great part to groups which are most largely represented at present in the mountainous parts of the warm belt of the northern temperate zone, in both the eastern and western hemispheres. Some of them, however, are of floral types which are to-day most highly developed in the tropics, such as the species of *Arundinaria*, *Berchemia scandens*, *Cissus ampelopsis* (*Ampelopsis cordata*), *Aralia spinosa* and *Symplocos tinctoria*. Yet the groups to which several or all of these species belong, formerly had a much wider extra-tropic distribution than is now the case.

To be considered in connection with this second category of species is a very significant group of genera which are represented in eastern North America by two closely allied species, one in the coastal plain, the other in the Appalachian region. With the exception of *Clethra* (which is largely tropic) all these genera, like many of those represented by species of the second category, have their present center of distribution in the warmer part of the north temperate zone. This may also be said of the larger groups to which many of them belong, e. g. the families Calycanthaceae, Sarraceniaceae, Hamamelidaceae and Monotropaceae and the tribes Hydrangeae of Saxifragaceae and Andromedeae of Ericaceae. Some of them are known to belong to floral types which were very widely distributed in the northern hemisphere during the early part of the Tertiary, in not a few cases ranging as far north, as Greenland and Alaska. Several of these genera, broadly speaking, appear to be on the wane, as distinguished from the dominant and aggressive types of presumably neotropic origin to which species of the first category chiefly belong. The following list, according to KEARNEY, includes some of the plants which are represented by the same or closely related species found in the Appalachian region and also in the coastal plain, viz.

| Genus | Coastal Plain Species | Appalachian Species |
|---|---|---|
| Calycanthus (Butneria) | florida L. | glauca Willd. (= fertilis Walt.) |
| Sarracenia | flava L. | flava var. oreophila |
| Philadelphus | grandiflorus Willd. | inodorus L. |
| Hydrangea | quercifolia Bartr. | radiata Walt.<br>cinerea Small |
| Fothergilla | Gardeni Murr. (= carolina L.) | arborescens L. |
| Stuartia | virginica Cav. (= Malacodendron L.) | major Lodd. |
| Schweinitzia (Monotropsis) | Reynoldsiae Gray | odorata Ell. |
| Leucothoë | axillaris D. Don.<br>racemosa Gray. | acuminata D. Don.<br>Catesbaei Gray. |
| Andromeda (Pieris) | phillyreifolia Hook. | floribunda Pursh. |
| Halesia (Mohrodendron) | diptera L.<br>parviflora Michx. | carolina L. (= tetraptera L.) |

## 5. Relationship in Western North American Flora.

*Rocky Mountain Flora; its Affinities.* The Rocky Mountain Region may for the purposes of our comparison be divided vertically into three belts:

1. An alpine treeless belt above the belt where trees grow.
2. A wooded belt, in some places covering, in others locally adorning, the mountain slopes.

3. An arid and woodless belt which occupies by far the greater part of the region.

Botanically the alpine regions of the temperate zone in the northern hemisphere are southward prolongations of arctic vegetation, almost pure in the boreal parts, but more and more mixed with special types in lower latitudes, these special types being part of the flora which is characteristic of each continent in those latitudes. Leaving out of view a considerable number of temperate species which here and there become alpestrine, or persist in dwarfed forms within some truly alpine regions, the alpine flora of the United States does not comprise a large number of species.

The bulk of the forest of the Rocky Mountains[1]) consists of coniferous trees. Most of these are common to the region of the Pacific Coast, but none of the trees are found in the Alleghany Mountains or around the Great Lakes. The white spruce, *Picea alba (canadensis)*, has been reported from northern Montana and Alberta, but probably erroneously; *Picea columbiana*, which resembles it in habit and the glabrous branches, has been mistaken for it. *Picea columbiana* is otherwise much more closely related to *P. Engelmanni*. Two prostrate shrubby species of *Juniperus*, *J. sibirica* and *J. prostrata* range across the continent. Both are sub-arctic and sub-alpine. Besides these none of the Rocky Mountain conifers are found in the east, although they are often represented there by closely related species[2]). (See ante Chapter 3, § 4.)

Among the deciduous trees and shrubs, the number of species common to the Rocky Mountains and the East is much larger. Many of these common species are boreal, but some are truly transcontinental or nearly so. Of the Salicaceae about three-fifths of the Rocky Mountain species are endemic, or western. The rest are nearly all boreal. The only ones that cannot come under the categories, perhaps are *Salix Bebbiana*, *S. candida* and *S. cordata*. The eastern *Populus monilifera* (= *P. deltoides*) is represented in the Rocky Mountains by a western variety. Of the Betulaceae, *Betula papyrifera*, *B. glandulosa*, *Alnus viridis* (= *A. alnobetula*) and perhaps *Alnus incana* are found both in the Rocky Mountains and in the east. The other four Rocky Mountain species are western. Of Fagaceae, *Corylus rostrata* is common to the Rocky Mountains and the east. Besides by this species, the family is represented in the region by a few endemic low species of oaks of the white oak group.

Ulmaceae is represented by three or four species of *Celtis*, of which *C. occidentalis* is found in the east. *Ulmus americana* is found here and in the valleys of the Great Plains, but scarcely reaches the Rocky Mountains. All the woody species of Hydrangeaceae, Grossulariaceae, Rosaceae, Rhamnaceae, Drupaceae, Papilionaceae, Rutaceae, Aceraceae, Celastraceae and Anacardia-

1) Gray, Asa and Hooker, J. D.: The Vegetation of the Rocky Mountain Region and a Comparison with that of other Parts of the World. Survey VI, No. 1. 1880. Bulletin U. S. Geological and Geographical. Survey VI, No. 1. 1880.

2) Rydberg, P. A.: Composition of the Rocky Mountain Flora. Science new ser. XII: 871. Dec. 7, 1900.

ceae are endemic or western, except four species of *Ribes*, four of *Rosa*, *Rubus strigosus*, *Potentilla fruticosa*, *Sorbus (Pirus) sambucifolia*, *Prunus americana*, *P. pennsylvanica*, *Amorpha fruticosa*, *Rhamnus alnifolia*, *Negundo aceroides* and *Rhus glabra*, which are also found in the east. The two species of Vitaceae found in the Rockies, viz., *Vitis vulpina* and *Ampelopsis (Parthenocissus) quinquefolia*, extend to the Atlantic coast, and so also the three species of Elaeagnaceae.

Taken as a whole, scarcely 20 per cent of the woody plants of the Rockies are found in the Alleghany Mountains, or around the Great Lakes. Nearly all those common to both regions are transcontinental, or boreal species. If on the contrary, the woody flora of the Rocky Mountains were compared with that of the mountains of the Pacific coast, one would find that at least 50 per cent of the former would be represented in the northern Cascade Mountains, which in British Columbia are more or less contiguous to the Rockies.

*Affinities of Californian Flora.* It is important at this juncture to compare the flora of southern California with that of other floras in order to represent the affinities of one of the phytogeographic regions of the Pacific coast. Southern California is chosen, because, we have available for such a comparison in the statistics compiled by PARISH[1]).

The accompanying table exhibits the relations of the native genera and species of southern California to the flora of North America. The number of each which extend beyond the North American continent is shown; and those which are confined to it are separated into four geographic subdivisions; namely, those whose range is restricted respectively to southern California, to California, to the region west of the Rocky Mountains, and those which extend further eastward. While the line has been drawn very strictly between plants which are, or are not ex-

| Taxonomic Groups | Genera | | | | | | Species | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Endemic | | | | | | Endemic | | | | | |
| | North American | Western N. American | Californian | Southern Californian | Total | Extra North American | North American | Western N. American | Californian | Southern Californian | Total | Extra North American |
| Gamopetalae | 13 | 54 | 16 | 6 | 89 | 127 | 22 | 250 | 164 | 221 | 657 | 57 |
| Choripetalae | 9 | 42 | 11 | 7 | 69 | 190 | 55 | 259 | 207 | 187 | 708 | 105 |
| Dicotyledoneae | 22 | 96 | 27 | 13 | 158 | 317 | 77 | 509 | 371 | 408 | 1365 | 162 |
| Monocotyledoneae | 3 | 4 | 3 | 3 | 13 | 72 | 43 | 88 | 40 | 32 | 203 | 50 |
| Angiospermae | 25 | 100 | 30 | 16 | 171 | 389 | 120 | 597 | 411 | 440 | 1568 | 212 |
| Gymnospermae | — | 1 | — | — | 1 | 6 | — | 13 | 5 | 3 | 21 | — |
| Spermatophyta | 25 | 101 | 30 | 16 | 172 | 395 | 120 | 610 | 416 | 443 | 1589 | 212 |
| Pteridophyta | — | — | — | — | — | 20 | 4 | 9 | 2 | 6 | 21 | 20 |
| Total | 25 | 101 | 30 | 16 | 172 | 415 | 124 | 619 | 418 | 449 | 1610 | 232 |
| Per cent of native flora | 4 | 17 | 5 | 3 | 30 | 70 | 6 | 33 | 23 | 24 | 87 | 12 |

1) PARISH, S. B.: A Sketch of the Flora of southern California. Botanical Gazette XXXVI: 203—222, 259—279. Sept. and Oct. 1903.

clusively North American, as accurately as possible for those confined to western North America, a somewhat laxer rule has been observed for the two smaller subdivisions. These are merely politic, and have little phytogeographic significance, and the limits of many of their plants as yet are not known accurately. For these reasons they are included in the number accredited to California and to southern California, some plants which, while properly belonging to them, extend a little beyond their boundaries. This table brings out the distinctively west American character of the flora.

Two-thirds of the genera, it is true extend their range beyond North America; but of the remaining one-third, only 14 per cent are found east of the Rocky Mountains, while 86 per cent of this third are confined to the territory west of them, and of these about one half are restricted to California. This local differentiation is much more pronounced in the species than in the genera. Less than one-eighth of the indigenous species extend beyond North America. Among the North American species less than 8 per cent pass beyond the Rocky Mountains; of the species occurring west of the range nearly 60 per cent are exclusively Californian; of the Californian species over one-half are confined to the southern counties of the state. In the Pteridophyta, the species are about equally divided between those of North America and those of wider distribution, the development of the Gymnospermae is entirely North American; the Monocotyledoneae are 80 per cent North American, the Choripetalae 88 per cent, and the Gamopetalae 92 per cent.

Fig. 14. *Darlingtonia californica* Torr. The California pitcher-plant, native to boggy places at middle elevations in the Sierra Nevada of northern California to southern Oregon, flowering from May to July. After Die Natürlichen Pflanzenfamilien III 2, p. 246.

The coast islands of California show a few peculiarities worthy of mention. According to LE CONTE[1]), out of 296 species of plants collected on the island of Santa Cruz, no less than 48 are entirely peculiar to the coast islands, and 28 peculiar to Santa Cruz itself. Of the remaining 248 species, nearly all are

1) LE CONTE, JOSEPH: The Flora of the coast Islands of California in relation to recent Changes of physical Geography. Bulletin California Academy of Sciences, 8. Sept. 19, 1887.

distinctively Californian, that is, species peculiar to California are very abundant, while common American species, i. e. those common to California and other parts of North America are very few and rare. (See also ante, Chap. 3 § 5.)

## 6. Relationship of the Floras of Mexico, Central America and West Indies.

Without attempting exact definitions of boundaries, we may repeat that there are three distinct floral provinces to be recognized in Mexico and Central America. Thus part of Nicaragua, all of Costa Rica and Panama (Fig. 15) constitute a region of the neotropic province. Salvador, Honduras, Guatemala

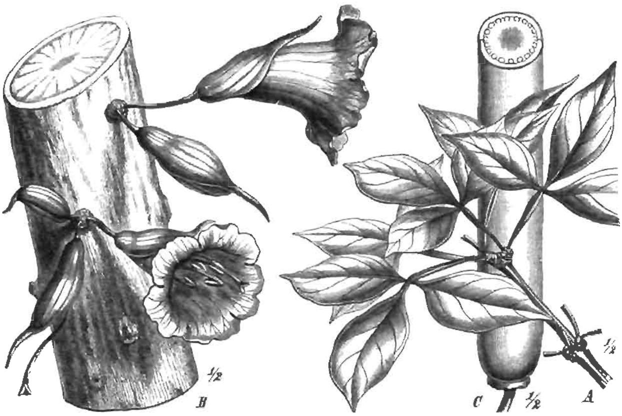


Fig. 15. *Parmentiera cerifera* Seem., the candle-tree of Panama, growing in the tropic forest formation and adorned with candle-like fruits a meter long at all seasons of the year. After Die Natürlichen Pflanzenfamilien IV 3 b, p. 247.

and south Mexico, south of the Isthmus of Tehuantepec form another region, while north Mexico with portions of western Texas, New Mexico and Arizona constitute another well defined region.

The California genera not represented in Mexico amount approximately to 350, where of 77 are peculiar[1]). They consist largely of herbaceous plants, with additional genera of the Coniferae and Cupuliferae; the latter in the north.

The expression "extensions into South America and the West Indies", used by HEMSLEY, is used for convenience and to avoid ambiguity, though strictly speaking the extensions are, as a rule, rather in the opposite direction. The

1) HEMSLEY, W. BOTTING: Biologia Centrali-Americana. Botany 1886—1888. IV: 223—235.

proportional distribution of Mexican and Central-American species in South America and the West Indies according to Hemsley is displayed in the accompanying table.

| | Common to both the West Indies and South America | West Indies only | Western South America only | Eastern South America only | Western and Eastern South America only | Numbers of South American types reaching Mexico or Guatemala, but not the West Indies |
|---|---|---|---|---|---|---|
| Polypetalae . . . . | 190 | 55 | 143 | 66 | 212 | 265 |
| Gamopetalae . . . . | 182 | 112 | 129 | 65 | 80 | 177 |
| Incompletae . . . . | 97 | 43 | 36 | 30 | 34 | 72 |
| Monocotyledoneae . | 179 | 71 | 64 | 99 | 103 | 183 |
| Gymnospermae . . . | — | 3 | 2 | 1 | — | 1 |
| Totals | 648 | 284 | 374 | 261 | 429 | 698 |

It should be mentioned that the divisions of South America into eastern and western regions is a very rough one, the main object in view being the separation of the western and Andine elements from the eastern. Thus Venezuela is reckoned eastern, and New Granada western.

Of the 1849 genera of vascular plants represented in Mexico and Central America, 787 recur in some part or parts of the old world, or in the Pacific islands, and of these, no fewer than 609 range widely, leaving only 178 which are restricted to one country or region outside of America. Of the 12,233 species, 454 extend beyond America; 337 of them are widely diffused, and the rest, 117 in number, are of comparatively limited range.

*Affinities of the Jamaican Flora.* The affinities of the flora of Jamaica to the other Antillean islands and the mainland displayed below was obtained by taking Fawcett's provisional list of the indigenous and naturalised plants of Jamaica (1893) and checking off the plants found also in the other islands and the mainlands adjacent. As this list is largely based on GRISEBACH, and as the other lists used also conform more or less closely to his nomenclature, the data necessarily, owing to our lack of information, are very incomplete and discrepancies occur. The following figures, however, have been given with the understanding that they suggest probable affinities, rather than absolute relationship, because the incomplete state of our knowledge of the flora of the West Indies and the absence of a complete systematic manual for any of the larger islands prohibits an exact statement of the facts. The true relationship of the flora of these several islands to Jamaica is only determined by excluding the littoral plants, weeds and other naturalized plants, as also the species of a wide range common to a number of the islands and the mainland (Fig. 16). The tabular matter expresses the relationship of the flora of Jamaica to Haiti, Cuba, the Bahamas, St. Croix, the southern United States, Mexico and Central America. Some peculiarities are worthy of mention which elucidate the probable past geographic distribution of the species, which comprising the Jamaica flora are found on other of the Antillean islands and the mainland. In the table.

*the Jamaican species are counted, which are common to the islands mentioned in the right hand column.*

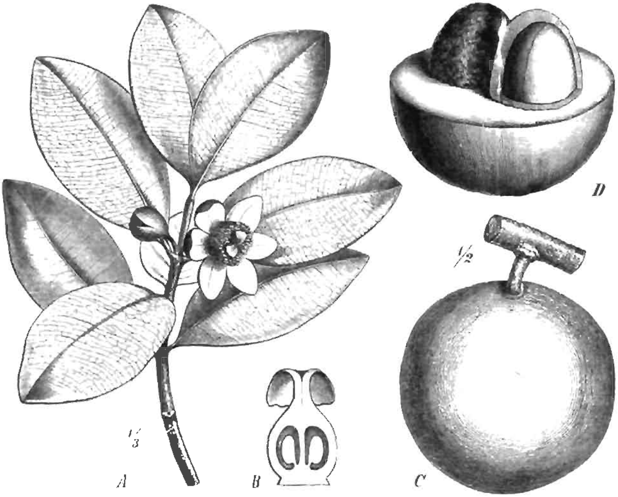


Fig. 16. *Mammea americana* L., mammee-apple, wild apricot; a large tree native to the West Indies and cultivated for its edible fruit. Tropic Forest Formation. After Die Natürlichen Pflanzenfamilien III 6, p. 220.

| Jamaican Plants Common to | Apopetalae | Gamopetalae | Incompletae | Monocotyledoneae | Gymnospermae | Total |
|---|---|---|---|---|---|---|
| Mexico, Central America | 5 | 2 | — | 10 | — | 17 |
| Cuba | 7 | 3 | 2 | 6 | 1 | 19 |
| Haiti | 66 | 127 | 60 | 80 | — | 333 |
| St. Croix | — | — | — | 1 | — | 1 |
| Cuba and Haiti | 70 | 79 | 28 | 71 | 2 | 250 |
| Cuba and Bahamas | — | 3 | — | 3 | — | 6 |
| Haiti and Bahamas | 8 | 5 | 4 | 3 | — | 20 |
| Haiti and St. Croix | 11 | 7 | 5 | 7 | — | 30 |
| Cuba, Haiti & St. Croix | 16 | 27 | 15 | 5 | — | 63 |
| Mexico, Central America, Haiti | 32 | 29 | 16 | 26 | — | 103 |
| Cuba, Haiti, Mexico, Central America | 59 | 44 | 21 | 54 | — | 178 |
| Cuba, Haiti, Bahamas | 15 | 13 | 8 | 6 | — | 42 |
| Cuba, Haiti, St. Croix, Mexico, Central America | 20 | 18 | 8 | 11 | — | 57 |
| Cuba, Haiti, Mexico, Central America, Southern United States | 8 | 5 | 5 | 13 | — | 31 |
| Cuba, Haiti, Bahamas, Southern United States | 7 | 4 | — | 1 | — | 12 |
| Cuba, Haiti, Bahamas, Mexico, Central America | 9 | 11 | 5 | 5 | — | 30 |
| Cuba, Haiti, Bahamas, Mexico, Central America, Southern United States | 7 | 10 | 4 | 7 | — | 28 |

It is seen from this table that the closest relationship exists between the flora of Haiti and Jamaica, 333 species being common to both. If the flora of Cuba and Jamaica be compared directly, only 19 species are peculiar to both, whereas 250 plants common to Jamaica and Haiti are also found in Cuba. Seventeen phanerogams and gymnospermae are found in common in Mexico (Fig. 17) — Central America and Jamaica, while if those which are found in these countries, as well, as those which have extended their range to Haiti and Cuba, 178 species of indigenous plants are common to all these places. The affinity of the Jamaican flora to that of the island of St. Croix is interesting, but not dependable because based on incomplete lists. (See under Bahama Islands.) Only one species is peculiar to both according to our table, yet, if the species common to St. Croix, Jamaica, Cuba and Haiti are considered 63 plants are found in all. The plants which have extended themselves in Jamaica, Mexico — Central America and Haiti number one hundred and three. Britton (Science new ser. XXIV: 853) after a study of the Jamaican sedges holds that the South American relationship of the Jamaican flora is more intimate than that of Cuba, Haiti or Puerto Rico. However, the results given above can be tentative only until the recent collections of plants have been studied critically. It has been established that there is a strong interrelationship of the flora of the different islands and with the mainland of Central and South America, while the flora of the hammocks of southern Florida and the flora of the Bahamas are strongly West Indian.

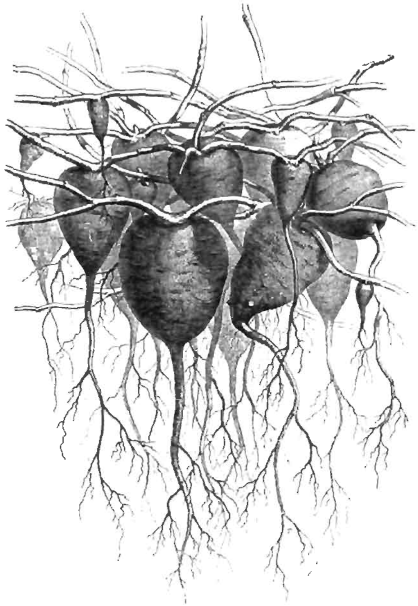

Fig. 17. *Exogonium Purga* Wend., jalap, a climbing plant native of the eastern slopes of the mountains of Mexico at an elevation of 5—8.000 feet in the tropic rain forest, cultivated for its cathartic roots. After Die Natürlichen Pflanzenfamilien IV 3a, p. 28.

*Bahama Islands.* The flora of the Bahaman islands shows a larger contingent of southern plants on account of the greater similarity of the climate, and because the prevailing winds and currents are from that direction. Taking the larger islands of New Providence and Andros, the total number of plants, exclusive of cultivated and escaped plants found on these islands is 453 species, according to ALICE R. NORTHROP of which are reported 176 species from other islands of the group, 335 from Cuba, 250 from south Florida, 108 from southern United States, 286 from Jamaica, 190 from Virgin Islands, 223 from Windward islands, 197 from Mexico and Central America and 199 from South America. Of the 453 species mentioned above, 76 are widely distributed, being common in warm countries on both continents.

The recent work of the botanists of the New York Botanic Garden and that of the scientists of the expedition of the Geographical Society of Baltimore have enlarged our knowledge of the flora of the Bahama Islands, so that the figures given above are true for the two larger islands and only approximately so. COKER [1]), the botanist of the expedition of the Baltimore Geographical Society has tabulated the results obtained by himself and others also the unpublished results of CURTISS, BRITTON and MILLSPAUGH.

He shows that of the 795 flowering plants and ferns indigenous to the Bahama Islands, 536 are common to that group and Cuba; 311 are common to the Bahamas, Mexico and Central America; 282 are common to the Bahamas and South America; 322 common to these islands and Florida; 170 common to the southern United States and the Bahama group and 55 species peculiar to the Bahama islands. It is evident that a study of the Bahama flora does not furnish any proof either for or against land connections either between Cuba on the one side, or Florida on the other, which we have assumed elsewhere to have been the case. At this point, it may be well to disclaim any intention on the part of the writer to emphasize that the migration of plants into newly elevated land has always been by means of land connections, or bridges. Ocean currents, winds, birds, and other agencies have been active, but on the other hand, a land connection emphasizes the probable continuity of a particular flora and also provides a way by which plants can enter new land areas raised from the ocean.

The majority of the plants common to the Bahamas and to the southern United States, extend also into other tropic countries, and it seems probable, that these more widely distributed species have invaded both the Bahamas and Florida from the south, namely from the larger islands which represent fragments of a formerly existing Caribbean landmass covered by the original American tropic flora. Of the 4?2 plants common to the Bahamas and the United States, there are 40 that are found only in these two regions.

In discussing the relationship of the Bahama flora, it is important not to

1 COKER, WILLIAM C.: Vegetation of the Bahama Islands. The Bahama Islands 1905: 194-201 Published under the auspices of the Geographical Society of Baltimore.

forget that the limestone soil and exposure to salt, the low elevation of the land, the drought and wind, to which the flora is subjected would preclude the occurrence in the Bahama islands of many groups of plants, such as Araliaceae, Piperaceae, Selaginellaceae, Lycopodiaceae, Equisetaceae, that are particularly partial to certain kinds of soil, or fresh water, shade and low temperature. For example Mrs. NORTHROP found on the damp open savannas of Andros, a considerable number of plants confined to that environment. They occur on New Providence island, where similar environmental conditions are found. The pines and cedars are confined to the northeastern group (New Providence, Andros, Great Bahama, Abaco and Berry islands), while the Cactaceae are mostly southern in their distribution [1]). There are at present, as far as our information permits us to go, 55 endemic species reported from the Bahama islands [2]), as follows:

Eragrostis bahamensis Hitch. Inagua.
Thrinax bahamensis Cook. New Providence. Andros, Green Bay, Eleuthera, Cat, Watlings.
*Paurotis androsana Cook.* Andros.
Cyclospathe Northropi Cook. Andros, Eleuthera.
Hymenocallis arenicola Northrop. New Providence, Andros.
Epidendrum altissimum Bateman. Cat, Eleuthera.
» gracile Lindl.
» rufum Lindl.
» bahamense Griseb.
Phoradendron Northropiae Urban. Andros.
Torrubia Cokeri Britton. Eleuthera.
Acacia choriophylla Benth. New Providence, Andros.
Pithecolobium mucronatum Britton. Long Island.
» bahamense *Northrop*, New *Providence*, Andros.
Cassia caribaea Northrop. Andros.
Caesalpinia ovalifolia Urban. New Providence, Andros.
» lucida Urban. New Providence, Eleuthera.
Mimosa bahamensis Benth. Fortune, Inagua.
Linum bahamense Northrop. New Providence, Andros.
Erythroxylon reticulatum Northrop. Andros.
Buxus bahamensis Baker. New Providence, Andros, Watlings.
Phyllanthus bahamensis Urban. Andros.
Euphorbia cayensis Millsp. Rum and Joulters Cays.
Salvia bahamensis Britton. New Providence.
Croton Hjalmarsonii Griseb. Fortune, Inagua.
Crossopetalum coriaceum Northrop. Andros.
Thouinia discolor Griseb. New Providence, Andros, Eleuthera, Cat, Fortune, Inagua.
Reynosia Northropiana Urban. Andros.
Sphaeralcea abutiloides Endl. New Providence.
Malvaviscus Cokeri Britton. Watlings,
Pavonia bahamensis Hitch. Fortune.
Helicteres spiralis Nortbrop. Andros. New Providence, Eleuthera.
Waltheria bahamensis Britton. New Providence.

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1) COKER, l. c. p. 200.
2) COKER, l. c. p. 197.

Xylosma ilicifolia Northrop. New Providence, Andros, Eleuthera.
Passiflora pectinata Griseb. New Providence, Andros, Turks.
*Bourreria thymifolia Griseb. Rum Bay, Turks.*
Terminalia spinosa Northrop. Andros.
Casearia bahamensis Urban. Andros.
Bumelia loranthifolia Pierre. New Providence, Andros, Eleuthera.
Metastelma Eggersii Schttr. Fortune.
» barbatum Northrop. New Providence, Andros.
Plumiera bahamensis Urban. Acklin.
Cordia bahamensis Urban. Fortune, New Providence.
Heliotropium nanum Northrop. Andros.
Tecoma bahamensis Northrop. New Providence, Andros.
Jacaranda bahamensis R. Br. Andros.
» caerulea Griseb. New Providence, Cat.
Catesbaea paniculata Northrop. Andros and Green Bay.
Scolosanthus bahamensis Britton. New Providence.
*Ernodea Cokeri Britton. Abaco.*
Stenostomum (Antirrhoea) myrtifolium Griseb.
Myrstiphyllum ligustifolium Northrop. Andros.
Anguria Keithii Northrop. Andros.
Eupatorium bahamense Northrop. Andros.
Vernonia bahamensis Griseb. New Providence, Andros, Cat, Inagua.

*Affinities of Bermuda Flora.* The flora of the Bermuda islands consists of 326 species belonging to 231 genera and 78 orders while the indigenous element consists of 144 species belonging to 109 genera and 50 orders arranged taxonomically, as follows:

| | Orders | Genera | Species |
|---|---|---|---|
| Dicotyledons | 37 | 74 | 85 |
| Monocotyledons | 10 | 23 | 35 |
| Vascular Cryptogams | 3 | 12 | 24 |
| | 50 | 109 | 144 |

The cellular cryptogams probably number 201 species comprising 8 mosses, 6 hepatic mosses, 31 lichens, 24 fungi and 132 algae showing that the lower flora is comparatively little known.

From HEMSLEY [1]) we learn that 109 species of the Bermudan flora inhabit southeastern North America and within one of the same number the West Indies. Further, eighty-six of the Bermudan plants are common to the West Indies and continental North America, or at least reach the Keys of Florida. It is only a comparatively small number of the eighty-six that does not reach the mainland of Florida, where there is a much greater overlapping of the essentially North American and the West Indian elements than was formerly suspected. To add tho these there are twenty-three West Indian species in the Bermudas

1) HEMSLEY, W. B.: Report on the Botany of the Bermuda, etc. Report of the scientific Results of the Voyage of H. M. S. CHALLENGER. Botany I. 1885. (These figures will have to be modified when the results of the exploration of the islands under the auspices of the New York Botanical Garden are published.)

not hitherto recorded from North America. Most of the foregoing are represented in North America by closely allied species, and there are twenty-two North American plants which are apparently indigenous in the Bermudas, but do not extend to the West Indies.

Of the 144 species comprising the indigenous flora, some 46 are widely dispersed, by which is meant that, independently of their distribution in the New World, they extend to some part of the Old.

As compared with other islands in similar and different latitudes and similarly situated to the nearest continents, the flora of the Bermudas is singularly poor in endemic species. The endemic element in the flora of the islands is limited, as far as known, to 11 species, namely, *Juniperus bermudiana*, *Galium bermudianum*, *Erigeron Darrellianus*, *Statice Lefroyi*, *Sisyrinchium bermudianum*, *Sabal Blackburniana*, *Carex bermudiana*, *Adiantum bellum*, *Asplenium Laffanianum*, *Nephrodium bermudianum* and a moss *Tortula bermudiana*.

## 7. Southern Extension of North American Flora.

*Relationship of North and South American Floras.* The relationship of the floras of North and South America will be discussed under the following heads: 1st, the Gulf neo-tropic, 2nd, the alpine and arctic-alpine and 3rd, the warm temperate and semi-tropic xerophilous elements embracing (a) high plateau and mountain forms of the transition and upper Sonoran climatic zones; (b) enclosed basin and valley forms of the lower Sonoran climatic zone; (c) semitropic xerophilous forms of Gulf distribution. It should be mentioned that the terms transition, upper Sonoran and lower Sonoran, proposed by MERRIAM, are used here in the sense of areas controlled by the same climatic conditions and not as defining phytogeographic regions, which according to the writer are not dependent altogether upon the temperate control of plant phenomena, but upon rainfall, relation of rainfall to evaporation, physiography and the historic element. According to BRAY[1]), the Gulf territory includes those regions which have had a common history in the development of their flora during the fluctuating geologic conditions of the Gulf area. While this zone is but a part of the greater neotropic, its association with a common sequence of geologic changes has as ENGLER thinks, given it a degree of distinctness from the Brazilian region. The regions so associated are: The coast lands, plains and sub-Andean parts of Guiana, Colombia and Venezuela; the Central American region except the tierra templada, the tierra fria of Guatemala and the isolated elevations (above 8000 feet) in Nicaragua and Costa Rica; the tierra caliente of Mexico which on the west reaches northward to include the lower Colorado Valley in California and Arizona, and embraces the point of the lower California peninsula, and on the east coast is a narrow belt extending northward to the lower Rio Grande Valley in Texas, the lower third of Florida and the Greater and Lesser

1) BRAY, W. L.: The Relations of the North American Flora to that of South America. Science new ser. XII: 712. Nov. 9, 1900.

Antilles. On the west, the tropic elements pass vertically rather than gradually into the vegetation of the tierra templada of Mexico and Guatemala, and at the north, a semitropic Gulf strip from the mouth of the Rio Grande to and including upper Florida, marks the transition to the subtropic flora of the Gulf states which, though distinctly a part of the Atlantic coast plain flora has numerous elements of tropic extraction as, for example, the Palmae, the Tillandsias (Fig. 18), some Euphorbiaceae (*Argithamnia*, *Acalypha*, *Sebastiana*, *Stillingia* and *Hippomane*), *Bignonia*, *Phoradendron*, *Persea* and many others.

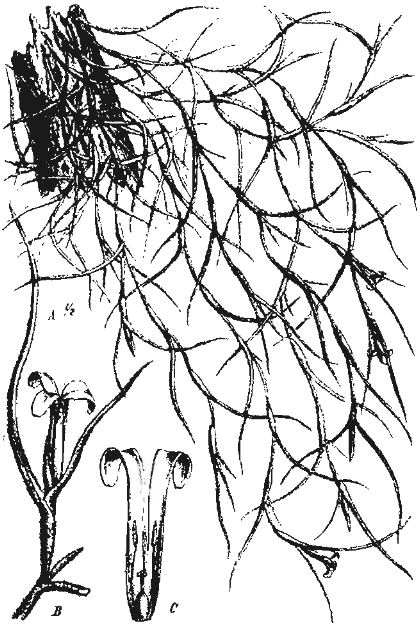


Fig. 18. *Tillandsia usneoides* L. Florida moss, an epiphytic bromeliaceous plant, festooning trees and shrubs in the subtropic coastal plains from Virginia to Texas and in Central America. After Die natürlichen Pflanzenfamilien II 4, p. 56.

At the west, the northward extension of the tropic flora is checked by xerophytic conditions, so that a very meager tropic element reaches the United States in that quarter. On the other hand, the free northward extension to the Florida province, whose physical conditions favor a purely tropic flora, has been retarded by interruptions in the continuity of the landmasses, so while the flora of south Florida is not a part of the Atlantic coastal plain flora and subtropic, it is comparatively meagerly provided with South American species. It has, however, many elements in common with the Antilles. The sharp distinction between south Florida and the remaining Gulf states and north Florida, is shown in the following data compiled by Drude from Chapman's Flora. There are 360 species in Florida which do not extend north of the 29th parallel; of these 169 belong to 132 genera which have no distribution further northward, or 16 families reach a northern limit in this peninsula. According to the discoveries of Dr. J. K. Small in the Miami neighborhood,

these figures will have to be considerably altered because of a large number of new species of West Indian affinity found there. The close relationship of the flora of the Florida hammocks, or everglade keys to that of the West Indies is now established by the fact that considerably more than one half of the species found on the islands south of Miami are also native in Cuba and the Bahamas.

It is interesting to note that some of the genera cited above, as marking the transition from tropic to sub-tropic United States, also extend into extra tropic South America, namely to Argentine. Those cited by ENGLER[1]) are *Arnithamnia*, *Bignonia*, *Lippia*, *Chaptalia* and *Galphimia*, to which may be added many amaranths and others.

We have given by MOHR[2]) some accurate statistic data as to the relationship of the flora of Alabama to those of the West Indies, Mexico and South America. Not less than 290 genera containing nearly 40 per cent of the plants indigenous to the Alabama flora are represented in the West Indian islands, Mexico, Central America and more rarely in South America, as far south, as Argentina. On the western coast of the continent, but a few genera occur which also occur in Alabama. About 140 species are common to Central America, Mexico and the West Indian islands. This relationship is most evident between the coastal plain flora and the flora of the more elevated regions of tropic America with climatic conditions somewhat similar to those prevailing in southeastern North America. The flora of the sub-tropic regions of Alabama exhibits, according to Mohr, the features of the vegetation of the neighboring tropics by the presence of a few genera of epiphytes, Tillandsia, Epidendrum, Polypodium. A stronger tropic character in this flora is afforded by the presence of the dwarf palmettos, *Sabal*, *Serenoa*, while the deciduous-leaved trees are represented by ten genera common to both regions. The slash pine or Cuban pine *Pinus heterophylla* (= *P. caribaea*, *P. bahamensis*, etc.) extends from the West Indian islands to Honduras; *Taxodium* inhabits Mexico and the savin, *Juniperus barbadensis* the West Indies with other species of *Juniperus* in Mexico.

The following plants common to the southern United States and Venezuela have been listed by A. ERNST[3]) of Caracas. The enumeration of the species is derived from the observations of Ernst compared with CHAPMAN's Flora (New York 1860).

| Divisions | Number of species in CHAPMAN's Flora | In Venezuela | Per cent |
|---|---|---|---|
| Apopetalae . . . . . | 768 | 81 | 10.55 |
| Gamopetalae . . . . | 935 | 90 | 9.63 |
| Apetalae . . . . . . | 236 | 36 | 15.25 |
| Gymnospermae . . . | 20 | — | — |
| Monocotyledoneae . | 655 | 60 | 9.16 |
| Cryptogamae . . . . | 70 | 16 | 22.85 |
| Totals | 2684 | 283 | 10.54 |

1) ENGLER, A.: Entwickelungsgeschichte II: 189.
2) MOHR, CHARLES: Plant Life of Alabama. P. 41.
3) ERNST, A.: On the Plants common to the southern United States and Venezuela. Journal of Botany British and Foreign V: 290—296. 1867.

*Arctic and Arctic-Alpine Flora.* An analysis of the floral elements of the north-south arctic and arctic-alpine flora distributed along the elevated continental axis from Alaska to Cape Horn and broken only from the southern downfall of the Guatemalan highland 15° N. to the Colombian Andes 5° N. shows the following interesting phenomena. 1. The flora of the higher Rocky and Sierra Nevada Mountains, the Mexican Cordilleras (8,000 to 12,000 feet) of the Guatemalan tierra fria and the tropic Andes (above 12,500 feet) is one of northern extraction, abounding in genera associated with the colder zones of North America, Europe and Asia. Such for example, are: *Ranunculus*, *Anemone*, *Berberis*, *Geranium*, *Spiraea*, *Geum*, *Rubus*, *Ribes*, *Saxifraga*, *Hydrocotyle*, *Gaultheria*, *Vaccinium*, *Veronica*, *Eritrichium*, *Gentiana*, *Polemonium*, *Hieracium* etc.

2. While possessing many genera in common, by far the greater per cent of species in the Mexican cordilleras are endemic, as are those of the alpine Andes. This points to a long and effective isolation of the Mexican and South American Andes from each other and from the Rocky Mountains. 3. The arctic-alpine genera are the most common which belong to the element common to the Himalayan and east Asiatic regions and the Rocky Mountains from Alaska to Colorado. Such genera occur sparingly in the Mexican and tropic Andes, and then with endemic species. There is an increase of this element in the extra-tropic Andes toward the Straits of Magellan. Here should be noted the fact that certain species of the Rocky Mountain arctic-alpine region reappear in the extra-tropic Andes toward the southern extremity of South America, being so far as known absent from the Mexican and tropic Andes. Among these are: *Gentiana prostrata*, *Trisetum subspicatum*, *Primula farinosa*, and var. *magellanica*, *Draba incana* (*D. magellanica*), *Alopecurus alpinus* (*A. antarcticus*), *Saxifraga caespitosa* (*S. cordill.rarum*), *Polemonium micranthum* (*P. antarcticum*), *Collomia gracilis*[1]).

*Warm Temperate and Subtropic Xerophilous Elements.* The warm temperate and sub-tropic xerophilous elements common to North and South America deserve special emphasis. They embrace for the most part, the flora of the arid regions of the western and south-western states and north Mexico. This flora occupies the mountain slopes of the transition climatic zone and plateaus of the upper Sonoran and the hot deserts of the lower Sonoran climatic zones. This area has been the field of development of many groups peculiarly American. It is the region of xerophytic composites, Nyctaginaceae, Polygonaceae-Eriogoneae, Onagraceae, Amaranthaceae-Gomphreneae, Malvaceae, Boraginaceae-Eritricheae, Gilias, the Yucca and the Agave kinships (Fig. 19, 20) and the Cactaceae.

When this peculiar flora was in the vigor of its development and occupation of new territory, the climatic conditions seem to have exerted a pressure

1) See ante page 302, and compare the views of GADOW: Altitude and Distribution of Plants in Southern Mexico. Journal Linnaean Society. Botany. XXXVIII: 429—440.

to the southward which geologic conditions favored, with the consequence of carrying a great richness of forms into the South American region. There has also apparently, been an encroachment of elements developed in South America northward, as shown in the Loasaceae (*Mentzelia*) and species of *Prosopis*, whose great development occurs in the Chilean and Argentine regions respectively.

Greater details of distribution may be discussed as follows: (1) the mountain forms; (2) forms of the arid basins and valleys of the lower Sonoran climatic zone; (3) sub-tropic xerophilous forms of Gulf distribution. According to BRAY, the mountain

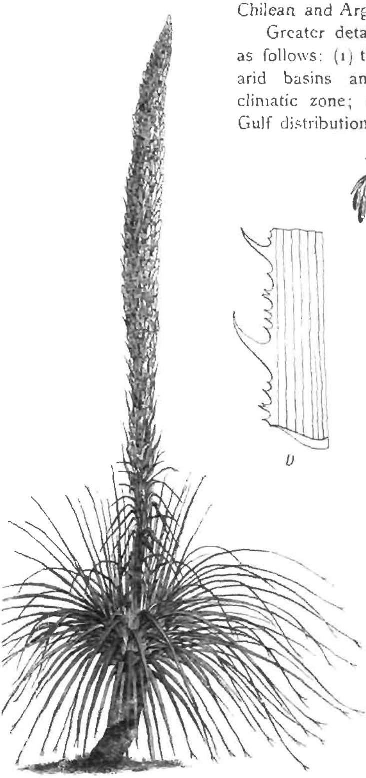


Fig. 19. *Dasylirion acrotrichum* Zucc. a desert plant native of the Mexican tableland with stem 1.5 m high, stiff spiny-margined leaves and flower-spike 2—3 m long. After Die Natürlichen Pflanzenfamilien II 5. p. 72.

Fig. 20. *Beschorneria yuccoides* Hook., a Mexican xerophyte frequently cultivated. After Die Natürlichen Pflanzenfamilien II 5. p. 116.

xerophilous Sonoran elements occupy the arid mountain slopes and high plateaus of the transition and upper Sonoran climatic zones, extending also into the deserts of the lower Sonoran climatic zone. Its southward distribution

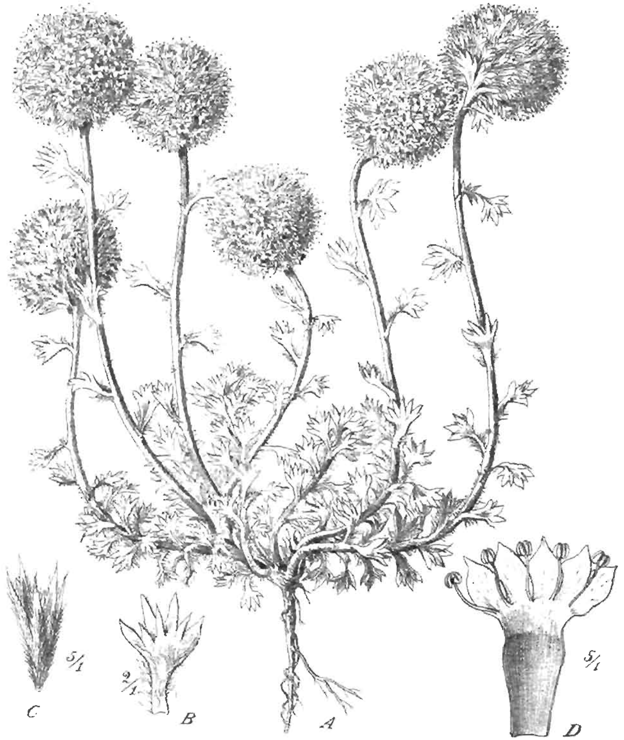


Fig. 21. *Gilia congesta* Hook., a perennial, wooly plant with densely clustered white flowers, native to the Sierra Nevada and Rocky Mountains at an elevation of 10,000 feet. After Pflanzenreich Abtlg. IV 250, p. 122.

has been favored by the existence of an arid zone comprising the moistureless west slopes and enclosed plateaus of the Mexican and tropic Andes, lying mostly below the altitudes of alpine conditions. Both the aridity and continuity of this zone have been varied with the changes in elevation, and in all

probability a north-south distribution of xerophilous mountain elements was much easier at some earlier period than at present. Illustrations include xerophilous ferns of 6 genera, many of which range from west Texas, New Mexico, Arizona, etc., to Mexico, Guatemala and in the South American Andes to Chili. The illustrations afforded by the Leguminosae include such genera, as *Astragalus*, *Dalea*, *Lathyrus*, *Lupinus*, *Vicia*. Other orders represented are Rosaceae-Quillajeae; Compositae-Astereae, Compositae-Solidagineae; Cactaceae; Boraginaceae-Eritricheae. The genus *Gilia* (Fig. 21) is included as well as many others. *Gilia* includes some eighty North American species and about fifteen Chilian species.

| Western North America. | Chili. |
|---|---|
| Gilia laciniata Ruiz & Pav.<br>» multicaulis Benth.<br>» achillaefolia Benth. | Gilia laciniata Ruiz & Pav. |
| » inconspicua Sweet (= G. parviflora Spreng.). | » crassifolia Benth.<br>» copiapina Phil.<br>» longifolia. |
| » intertexta Stend. | » involucrata (incl.<br>» Navarretia Steud., and<br>» eryngioides Lehm.) |
| » minima A. Gray. | dwarf forms of G. involucrata in Chili. |
| » pusilla Benth. | Gilia pusilla Benth. |
| Collomia linearis Nutt. | Collomia coccinea Lehm. |
| » grandiflora Dougl.<br>» gracilis Dougl. | |
| Polemonium micranthum Benth. | Polemonium antarcticum Griseb. (= P. micranthum Benth.). |

The most extreme xerophytes and halophytes occupying the most arid deserts of both North and South America in the extra-tropic regions, and generally unrepresented in the moist tropic and high mountain areas between. Such are the Mimoseae, *Prosopis* § *Strombocarpa* with 3 species in Argentine; 3 species in west Texas, north Mexico and westward; § *Algarobia* with 19 species mostly in Argentine; but including *Prosopis juliflora* of wide range; Polygonaceae-Eriogoneae with eleven genera characteristic of southern California and adjacent arid regions (except some *Eriogonum*) and the peculiar subgenus *Chorizanthopsis* of *Chorizanthe*, endemic in Chili, and three species common to both zones, namely, *Oxytheca dendroidea*, *Chorizanthe commissuralis* and *Lastarriaea chilensis*, all originally from the Californian region; Frankeniaceae with the very distinct *Frankenia Jamesii* of the west Texas region, *F. Palmeri* of the southern California region, *F. triandra* of the Puna region six nearly allied Chilian species, one of which is in California and Arizona, and *Niederleinia juniperoides* of the Argentine salt steppes, more nearly related to the lower Sonoran than to the Chilian species. The largest genus of Loasaceae furnishes many desert species for the Atacama and Argentine deserts, and while developed mostly in these regions and in the Andes, some species push north

into Mexico (*Saccatae*, 13 species, including *Loasa triphylla*, Peru to Mexico). *Mentzelia* is the genus, however, most conspicuous because of its distribution in the two zones under discussion, although quite abundantly distributed elsewhere, and particularly along the intervening Andes[1]. These, apparently, constitute remnants of a previously widespread development. Perhaps no plant is more prominent as an indicator of extreme desert areas than *Larrea mexicana*

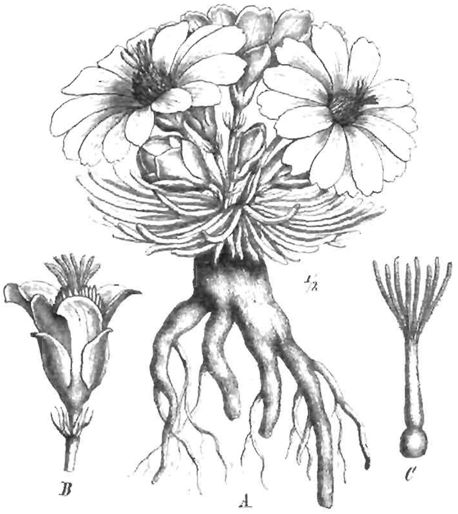


Fig. 22. *Lewisia rediviva* Pursh, the bitter-root, spatlum; an acaulescent, fleshy perennial with large rose-colored flowers, native of the mountains of California and extremely tenacious of life. Root used by Indians as food. After Die natürlichen Pflanzenfamilien III 1 b, p. 60.

which is abundant and widespread. This genus is represented at the Rio Colorado by three species which are sharply distinct from each other and from *Larrea mexicana*. The intervening territory between Mexico and South America is without a representative of this genus.

The critic work done by Professor ENGLER[2] on the family Zygophyllaceae makes it of special value for our purpose. With few exceptions the Zygophyl-

1) BRAY, W. L.: On the Relation of the Flora of the Lower Sonoran Zone in North America to the Flora of the Arid Zones of Chili and Argentine. The Botanical Gazette XXVII: 121. 1898.

2) ENGLER, A.: Geogr. Verbr. der Zygoph. in Verh. zu Syst. Glied. Abh. Königl. Preuss. Akad. d. Wiss. zu Berlin, 1896. BRAY, l. c. p. 133.

laceae in the western hemisphere are limited to the lower Sonoran climatic zone in North America and its corresponding zone in Chili and Argentine. The following is a tabular statement.

| North America. | West Indies, S. Brazil, Northern So. America. | Chili, Argentine. |
|---|---|---|
| Fagonia cretica L. var. californica Benth. | | Fagonia cretica L. var. californica Hook. |
| Guaiacum parvifolium Planch. Mexico. | Guaiacum officinale L. Fla., Antilles, Guiana, Venezuela. | |
| Guaiacum Coulteri A. Gray. Mexico. | Guaiacum sanctum L. Fla., Bahamas, Antilles, Guatemala. | |
| Porlieria angustifolia A. Gray. Texas. Mexico. | | Porlieria hygrometra Ruiz & Pav. N. Chili, Peru. |
| | | Porliera Lorenzii Argentine. |
| | Bulnesia arborea Engl. Columbia, Venezuela. | B. Bonariensis Griseb., Schickendantzii Hieron., chilensis C. Gay, foliosa Griseb., macrocarpa Phil., Sarmienti Lorentz. |
| Larrea mexicana Moric. | | Larrea divaricata Cav., cuneifolia nitida Cav. |
| Tribulus terrestris L. | Tribulus terrestris L. | Tribulus terrestris L. |
| Tribulus californicus S. Wats. S. Ariz., Lower California. | | |
| Tribulus brachystylis. Mexico. | | |
| Tribulus (Kallstroemia) maximus. S. Texas, N. Mex. | Tribulus (Kallstroemia) maximus L. | Tribulus (Kallstroemia) maximus L. |
| Tr. (Kallstroemia) grandiflorus B. & H. Texas to California. | | |
| Viscainoa gemmulata Lower California. | | |
| Cbitonia mexicana Moc. & Sesse. | | |
| Sericodes Greggii A. Gray. N. Mexico. | | |
| Peganum mexicanum A. Gray. N. Mexico. | | |

The semi-tropic xerophilous forms of Gulf distribution occupy the Rio Grande plain in Texas and Mexico below Eagle Pass. Such species also occur in areas of Colombia, Venezuela, Guiana, Brazil, Uruguay, Paraguay and Argentine and in similar areas of the Antilles. Some are undoubtedly sea-coast species. According to BRAY the following plants are illustrations.

Sida leprosa. Uruguay, Patagonia, Argentine, Cuba, north to Washington City.

Sida hastata A. St. Hil. Argentine, Uruguay, Mexico, Texas, Arizona.

Sida anomala A. St. Hil. Mattogrosso, Uruguay, Argentine, Bolivia, Cuba, Florida, Texas, Mexico.

Fugosia (Cienfugosia) sulphurea Garcke. Southwest Texas, Mexico, South Brazil, Paraguay.

Spergularia platensis Fenzl. Texas to California, South Brazil.

Polygala paludosa A. St. Hil. Brazil. Paraguay, Louisiana and Texas.

It is appropriate to conclude these comparisons with the floras of extra-American regions with an expositions of the extensions southward through the Andes and the antarctic islands to Australia and New Zealand. The examples are not numerous, but they are unmistakable.

## Mexican Genera and Species of otherwise mainly Andine, Antarctic and Australian Distribution.

| Genera and Species. | Distribution. |
|---|---|
| Drimys. | Andes to Cape Horn, N. Zealand, Australia, northward to Borneo. |
| Colobanthus. | Andes, Heard, Kerguelen, and St. Paul Islands, Australasia. |
| Colobanthus quitensis Bartl. | Andes to Cape Horn, N. Zealand. |
| Claytonia. | Andes, Australia. |
| Calandrinia. | Southward to Chili and in Australia. |
| Malvastrum spicatum A. Gray. | Southward in America and in Australia. |
| *Coriaria thymifolia Humb. & Bonpl.* | *Temperate S. America, N. Zealand.* |
| Acaena. | Andes, Antarctic islands, Australasia. |
| Oenothera. | America and one species in Tasmania. |
| Fuchsia. | America and three or four species in New Zealand. |
| Oreomyrrhis. | Andes, Australasia. |
| » andicola Endl. | Andes, Australia, N. Zealand. |
| Crantzia. | America, Australia, N. Zealand. |
| » lineata Nutt. | » » » |
| Daucus brachiatus Sieber. | » » » |
| Nertera depressa Banks & Soland. | Andes, Tristan da Cunha, Australasia, Sandwich Islands. |
| Flaveria. | Southward to Chili and in Australia. |
| Erechthites. | America, Australia, N. Zealand. |
| Microseris. | N. America, Chili, Australia, N. Zealand. |
| Pernettya. | Chili, Tasmania, N. Zealand. |
| Lucuma. | S. America, Australia, N. Caledonia. |
| Breweria. | America, Australia. |
| Nicotiana. | » » Polynesia. |
| Calceolaria. | Andes to Patagonia and the Falklands and in N. Zealand. |
| Muehlenbeckia. | Andes, Australasia, Polynesia. |
| Mollinedia. | S. America, Australia. |
| Roupala. | S. America, N. Caledonia. |
| Orthrosanthus. | Andes, Brazil, Australia. |
| Uncinia. | W. Indies, Andes, Antarctic islands, Australasia and the Sandwich Islands. |
| Distichlis. | Andes, Australia. |

The foregoing list shows that there is a connection between the antarctic and andine floras, a connection that is more evident when the comparison is made to include American plants not extending northward to Mexico. The most pregnant fact, according to HEMSLEY, is that the genera are almost without exception much more strongly developed in America than they are in Australasia and the antarctic islands. But if we take the vegetation generally of the southern coldest zone and regions, the preponderance of what may be called American types, in contradistinction to those which are more fully represented in the Australian region is not so great.

## Chapter V. North American Phytogeographic Classifications.

Rehearsing the classifications which have been made of the phytogeographic regions of North America, one of the first most consistent attempts is presented in MEYEN'S Grundriss der Pflanzengeographie (1836),[1]) translated by MARGARET JOHNSTON into English and published by the Ray Society in 1846. Meyen divides the horizontal range of vegetation into zones and the phytogeographic regions are consciously included in these world encircling zones, viz., equatorial zone; tropic zone; sub-tropic zone; warmer temperate zone; colder temperate zone; sub-arctic zone; arctic zone, and polar zone. The vegetation of North America is referred in the most general way to these several zones, which are more or less determined by the temperature of the air and not by the physiographic character of the country. His division based on the vertical range of vegetation need hardly be referred to here.

Under the notion of separate centers of development, the most important classification of the land areas of the globe into vegetation regions is that of GRISEBACH. By this writer twenty-four regions are recognized, the following only concerning this discussion, viz.,

I. Arctic Region.
XII. Forest Region of the Western Continent.
XIII. Prairie Region.
XIV. Californian Coast Region.
XV. Mexican Region.
XVI. West Indian Region.
XVII. Ciseqnatorial South American Region.

ENGLER[2]) divides the surface of the globe into four principal realms (Florenreiche), each of these into regions and each region into provinces, according to his theories of general development and migration. The regions of the continent of North America come under two realms. The regions and provinces where published by this well known author in a new form in 1902 (see p. 344).

1) Confer the Bibliography p. 46—51.

2) ENGLER, A.: Versuch einer Entwicklungsgeschichte II: 334—347; also MACMILLAN, C.: The Metaspermae of the Minnesota Valley, 1892, p. 589.

DRUDE[1]) gives the following useful summary of the vegetation-regions of *North America transcribed in the original German.*

1. Gletscherwald- und Strauchregion von Alaska mit arktischer Glacialflora.
2. Die Kanadische Waldregion.
3. Waldregion des nordamerikanischen Seengebietes.
4. Columbische Küstenwaldregion.
5. Die Wald- und Hochgebirgsregion der nördlichen Rocky Mountains.
6. Nördliche Waldprairieregion.
7. Die Missouri-Prairieregion.
8. Steppen- und Salzwüstenregion der Rocky Mountains.
9. Kalifornische Niederungs-Bergwald- und Hochgebirgsregion.
10. Sommergrüne Laubwaldregion des Mississippibeckens.
11. Die immergrüne Vegetationsregion der südatlantischen Staaten.
12. Steppen- und Wüstenregion von Arizona.
13. Chaparal-Vegetationsregion von Texas und Nordmexico.
14. Die nordmexicanische Bergwald- und Hochgebirgsregion.
15. Mexicanische Übergangsregion zu Californien und Texas.
16. Mexicanische subtropische Bergwaldregion (Tierra templada).
17. Mexicanische Hochgebirgsregion (Tierra fria).
18. Mexicanische subtropische Steppenregion.
19. Die tropische und subtropische Vegetationsregion von Nicaragua und Costa Rica.
20. Antillen- und Bahamaregionen.
    a) Die dürre Croton- und Cacteenregion.
    b) Die antillanische Tropenregion.
    c) Die antillanische Bergwaldregion.
    d) Die antillanische Hochgebirgsregion.

MERRIAM 1898 states that the northward distribution of terrestrial animals and plants is governed by the sum of the positive temperature for the entire season of growth and reproduction, and that the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year. Applying these principles, Merriam divides North America into three primary transcontinental regions (better to be named «zones»), viz., the Boreal, the Austral and the Tropical.

The distinctive temperature of the three boreal zones (Arctic, Hudsonian and Canadian) are not positively known, but the southern limit of the boreal, as a whole, is marked by the isotherm of 18° C. (64.4° F.) for the six hottest consecutive weeks of the summer. It seems probable that the limiting temperature of the southern boundaries of the Hudsonian and Arctic zones are respectively 14° C. (57.2° F.) and 10° C. (50° F.) for the same period. Transition zone species require a total quantity of heat of at least 5.500° C. (10,000° F.), but cannot endure a summer temperature the mean of which for the six hottest consecutive weeks exceeds 22° C. (71.6° F.). The northern boundary of the transition zone is marked by the isotherm showing a sum of normal positive temperatures of 5.500° C. (10.000° F.), while its southern boundary is coincident with the isotherm of 22° C. (71.6° F.) for the six hottest consecutive weeks. The transition zone comprises according to Merriam three principal subdivisions; an eastern, or Alleghanian humid area; a western arid area, and a Pacific coast humid area.

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1) DRUDE, OSCAR: Handbuch der Pflanzengeographie, 1890; cfr. Atlas der Pflanzengeogr., Bibliography, p. 40.

The Upper Austral *species require a total quantity of heat of at least* 6.400° C. (11.500° F.), but apparently cannot endure a summer temperature the mean of which for the six hottest consecutive weeks exceeds 26° C. (78.8° F.). The northern boundary of the Upper Austral zone, therefore, is marked by the isotherm showing a sum of normal positive temperatures of 6.400° C. (11.500° F.), while its southern boundary agrees very closely with the isotherm of 26° C. (78.8° F.) *for the six hottest consecutive weeks.*

MERRIAM[1] recognizes two principal subdivisions of this zone, viz., an eastern or Carolinian area and a western or upper Sonoran area. The lower austral species require a total quantity of heat of at least 10 000° C. (18.000° F.). The northern boundary of this zone, therefore, is marked by the isotherm showing a sum of normal positive temperature of 10.000° C. (18.000° F.). *This zone comprises an eastern or Austroriparian area and a western or lower Sonoran area.*

Tropical species require a total quantity of heat of at least 14.400° C. (26.000° F.), and, since the tropic life region is a broad equatorial belt, it is probable that both its northern and southern boundaries are marked by the isotherm showing a sum of normal positive temperatures of 14.400° C. (26.000° F.).

CLEMENTS[2]) proposes a classification of the phytogeographic divisions of North America and emphasizes the importance of using the Latin equivalents (f. ex. zona polari-nivalis, provincia alaskana, prov. cordillerana etc.) in order to avoid mistakes and to preserve a uniformity of treatment in phyto-geographic treatises. The following tabulation, omitting the latin names, represents his views on the subject.

Polar-nival Zone.

Arctic-alpine Zone. Arctic Prov., Alpine Province.

Boreal-subalpine Zone.
- Alaska Prov., Mountain Prov., Ontario Province.

Temperate Zone.
- Atlantic Prov., Appalachian Prov., Nebraskan Province.
  - *Prairie Region, with Elkhorn, Platte, Nemahadistrict.*
  - Sandhill Region, with Niobrara, Loup, Republicandistrict.
- Utah Province, with Nevada and Mohave Region.
- Litoral Province, with Columbia and California Region.
- Pacific Province.

Subtropical Zone.
- Florida Prov., Mexico Province.

Tropical Zone.
- Antilles Prov., Andean Province.

The most complete and satisfactory classification of the phyto-geographic regions of North America is one published by ENGLER[3]) in 1902 in a brochure which while primarily intended as a guide to the American plants in the new royal botanic garden at Dahlem-Steglitz near Berlin, is much more, because it gives an account of the characteristic plants and peculiar vegetation of the regions given below in the classification printed in the original.

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1) MERRIAM, C. HART: Laws of temperature Control. Dec. 1894. Also: Life Zones and crop Zones of the United States. 1898. (Bibliography, p. 49.)

2) CLEMENTS, FREDERIC E.: A system of Nomenclature for Phytogeography 1902. (Bibl., p. 46.)

3) See Bibliography, p. 47.

## Engler's Classification.

I. Arktisches Amerika.

II. Subarktisches Nordamerika.

a) Alaska-Bezirk, b) Peace- und Athabasca-River-Bezirk, c) Hudsonbay-Bezirk, d) Labrador-Bezirk.

III. Gebiet des Atlantischen Nordamerika.

1. Seenprovinz: A) Zone der Pinus strobus, B) Östliche Übergangszone der sommergrünen Laubwälder.
2. Provinz des sommergrünen Mississippi- und Alleghany-Waldes: A) Mississippi-Ohio-Tennessee-Zone, B) Alleghany-Zone, C) Zone der Pine barrens und des Strandes.
3. Immergrüne Provinz der südatlantischen Staaten: A) Küstenzone der Sumpfkiefer, B) Zone des Mischwaldes, C) Prairie-Wald-Zone, D) Südliche Kiefernwald-Zone.
4. Prairieen-Provinz: A) Nördliche Zone, α. Prairie-Gras-Formationen, β. Sandhügel-Formationen, γ. Formationen der Vorhügel, B) Mittlere Zone, C) Südliche Zone, Übergang zur Chaparal- und Sonora-Provinz des centralamerikanischen Xerophytengebietes.

IV. Gebiet des pacifischen Nordamerika.

1. Provinz der pacifischen Coniferen: A) Nördliche Zone, Bezirk des nördlichen Küstenwaldes und Bezirk ciskaskadischen Waldes und des Kaskadengebirges.
   B) Südliche Zone, Bezirk des Kalifornischen Küstenwaldes und Bezirk des westlichen Nevadawaldes und der Sierra Nevada.
2. Provinz der Rocky Mountains: A) Nördliche Zone, B) Südliche Zone, mit Übergang zur Chaparal- und Sonora-Provinz.
3. Westliche Prairieen-, Wüsten- und Salzsteppen-Provinz: A) Übergang von der Chaparal und Sonora-Provinz mit der Mojave- und Gila-Wüste, B) Zone des Great-Basin, C) Innere Kalifornische Zone.

The classification of the phyto-geographic zones, zone-sections and regions of North America by the writer is presented in the colored map. The plants which are peculiar to the different divisions, and which enable the botanist to distinguish the different phyto-geographic districts will be given in the Part IV. of this book. The classification presented herewith represents the writer believes the present state of our knowledge concerning the geographic distribution of American plants. In it is incorporated, all that is good in the classifications which have preceded without sacrificing originality. The endeavor has been to observe the law of priority by using the oldest name, except when the region to which the name has been applied, has not been found identic in the new and the old classifications. The author has felt himself free to apply a new name, when such a difference of territorial location has been discovered to exist. — In the construction of the map which accompanies this work, the excellent map of Merriam was first sketched in color upon the outline mother map of North America. The distribution of the principal forest trees was then depicted by a variety of character lines upon the colored face of the chart.

After a study of the general character of the North American flora, such well known botanic regions, as the prairie region, the tundra region, the region of the great interior basin, the Rocky Mountain region, etc. were outlined upon the map, particular attention being paid to the physiographic divisions, etc.

of the American continent as these influenced the distribution of plants. This gave a skeleton map on which to base subsequent research, which led to the completion of the map, as it finally appears. With the completion of the map in the rough, the unnecessary scaffolding, so to speak in the form of colored areas, lines and hachures were erased, leaving the finished chart, as a result of all the study that was put upon the distribution of North American plants in particular. The phyto-geographic map of Mexico was submitted to Dr. J. N. ROSE of the U. S. National Museum and Mr. CYRUS G. PRINGLE of the University of Vermont, whose invaluable criticisms were used in mapping the distribution of Mexican plants. The boundaries of the phyto-geographic zones, zone-sections and regions will be given in connection with a description of each area, and the reasons for the delimination of these districts have been given in a foregoing chapter III, p. 203—311.

# Part IV.

# North American Phytogeographic Regions, Formations, Associations.

Having presented in the foregoing part of this work a statement as to the affinities and probable origin, past and present distribution of North American plants, it is now the place to give a short account of the different phytogeographic zones, regions, formations and associations. *The consideration of the formations and associations of plant species will be made from* two view points: the ecologic and the phyto-geographic. Beginning with the Arctic Zone, the attempt will be made in what follows to give a succinct account of the vegetation of North America, not exclusively from the floristic standpoint, but also from the ecologic, as well. The endeavor will be to give a botanic description which will convey some adequate impressions of the appearance and constitution of the flora, as it forms one of the component parts of the landscape, setting off in artistic splendor our lakes, mountains, rivers, plains, deserts, hills and valleys. Necessarily, the description of the botanic regions must be short and very concise, because of the strictures imposed upon the writer by the lack of space*) to present adequately such an important subject.

## Chapter I. Arctic and Sub-Arctic Zones.

### 1. Arctic Regions of Labrador, northern Mackenzie and the Arctic Shore.

The flora of Arctic America may be divided into three districts: 1. that of Greenland, which is almost exclusively Lapponian, having an extremely slight admixture of American, or Asiatic types, 2. that of east America from the Mackenzie River to Baffin Bay, which shows a gradual transition to the 3. west American district, west of the Mackenzie basin. These latter districts will be considered alone in this work, because the transition in vegetation from the Greenland district to that of east America is comparatively very abrupt. Tundra conditions prevail over the greater part of this vast territory, where the ground remains perpetually frozen to an unknown depth, thawing out for only a foot or so on the surface during the summer. A large number of plants grow in the thin coat of soil resting upon perpetual frost. Wild bees able to pollinate the flowers abound and mosquitoes swarm by the millions.

*) Bemerkung der Herausgeber: Zwingende Rücksichten ließen es notwendig erscheinen, daß die von Prof. Dr. HARSHBERGER für Part IV eingesendeten Nachträge, besonders die ausführlichen Pflanzenlisten, in diesem "Survey" nur sehr verkürzt abgedruckt wurden.

The tundra in summer is always wet and boggy, as the frost prevents underground drainage. Its vastness, uniformity and solitude is impressive.

The Eastern arctic American flora differs from that of the western part of the continent in possessing more east American species. The western boundary is an artificial one, while the eastern, as previously mentioned, is a very natural one separated from Greenland by deep water. That portion of the region richest in plants is located between the Coppermine and Mackenzie rivers. Melville Island has a comparatively luxuriant flora, while the flora of the Boothian Peninsula, surrounded as it is with glacial straits and situated in the midst of arctic islands, is perhaps the poorest. The flora of Banks Land to the northwest in considerably richer, as are those of the shores of Lancaster Sound, Barrow Strait and the shores of Baffin Bay to the north and east. *Douglasia arctica* and *Pleuropogon Sabinii* are the only plants absolutely peculiar to arctic east America, while *Parrya arenicola*, *Festuca Richardsonii* are confined to arctic America (west and east). The following 35 plants are found on the arctic islands, and many of them on the west coast of Baffin Bay, but not in west Greenland[1].

1. Astragalus alpinus L.
2. Oxytropis (Aragallus) campestris [DC.
3. » uralensis DC.
4. » nigrescens Fisch.
5. Sieversia Rossii R. Br.
6. Arenaria (Merkia) physodes Fisch.
7. Stellaria crassifolia Ehrh.
8. Parrya arctica R. Br.
9. Caltha palustris L.
10. Saxifraga hieracifolia Waldst. & Kit.
11. » virginiensis Michx.
12. Androsace septentrionalis L.
13. » Chamaejasme Host.
14. Pedicularis capitata Adams: only W.-Greenl. 76—83° n.L.
15. » versicolor Wahl.
16. Phlox sibirica L.
17. Kalmia glauca Ait.
18. Achillea ptarmica L.
19. Artemisia vulgaris L.
20. Aster salsuginosus Hook.
21. Chrysanthemum arcticum L.
22. Crepis nana Rich.
23. Saussurea alpina DC.
24. Senecio frigidus Less.
25. » palustris Hook.
26. » pulchellus DC.
27. Solidago Virga-aurea L.
28. Nardosmia capitata.
29. Valeriana capitata Pall.
30. Salix phlebophylla Ander.
31. Deschampsia caespitosa Beauv.
32. Elymus mollis Trin.
33. Glyceria fluitans R. Br.
34. Hierochloë (Savastana) pauciflora R. Brown.
35. Pleuropogon Sabinei R. Br.: only W.-Greenl. 76—78° n. L.

The Western section of arctic America differs from that to the eastward by its far greater number both of European and Asiatic species. The

1) HOOKER, JOS. D.: Outlines of the Distribution of arctic Plants. Transactions of the Linnean Society of London XXIII: 269 (1862), gave a list of 38 plants, of which *Andromeda polifolia*, *Arctostaphylos alpina* and *Castilleja pallida* are now detected in western Greenland, also No. 14 and 35 of our emendated list (in the arrangement of WARMING, Tabellarisk Oversigt over Grönlands Flora 1887), which occur only in the forest north of western Greenland. (Drd.)

species peculiar to this territory are *Braya pilosa*, *Boykinia* (*Therafon*) *Richardsonii*, *Artemisia androsacea* (= *A. senjavinensis*), *Saussurea alpina* (= *S. subsinuata*), *Salix glacialis*, while many north temperate plants reach here the arctic region which are excluded from eastern arctic America by the rigors of the climate.

## a) Tundra Formation.

The tundra region of Alaska is low and gently undulating (see plate VII). Its flora is quite varied. Besides the numerous mosses and heathers and many small berry-bearing plants are dwarf willows, birches and alders. The alders attain the greatest size but grow in isolated clumps, often 6 to 8 feet high. The ground is frozen a few inches below the surface and the heavy, sponge-like covering of vegetation is constantly saturated. Upon such soil grow *Cassiope tetragona*, *Andromeda polifolia*, *Vaccinium vitis-idaea*, *Arctous* (*Mairania*) *alpina*, *Ledum palustre*, *Artemisia arctica*, *Rubus chamaemorus*, *Rubus arcticus*, *Betula nana*, *Alnus sinuata*, *Loiseleuria* (*Chamaecistus*) *procumbens* and *Nardosmia* (*Petasites*) *frigida*[1]: Eastward in the Barren Grounds of the Mackenzie basin occur *Cassiope tetragona*, *Ledum palustre*, *Rhododendron lapponicum*, *Arctostaphylos uva-ursi*, *Dryas integrifolia* and several dwarf willows. The crowberry *Empetrum nigrum*, occurs in the greatest abundance along the northern border of the more or less stunted timber at tree limit.

Occasional high bluffs on the coast in exposed situations are bleak and bare, but besides these there is scarcely an area not covered by low, matted vegetation. Numerous small ponds are irregularly distributed over the Alaskan tundra and around them the vegetation is ranker than elsewhere. It appears that a favorable combination of soil, shelter from winds, and full exposure to the sun have more to do with the development of flowering plants in polar regions than parallel of latitude. For in polar regions the sunlight is less intense, as well as more constant, lasting as it does for half of the year, but it is also more diffuse, the solar rays being forced to pierce a much thicker atmospheric stratum. The stems of such plants as grow under these conditions are more highly developed than in alpine regions, floral colors are paler, the foliage is less rigid and thick, and the blossoms are smaller. These points are of physiognomic importance in recording the ecologic character of the vegetation of the American north polar region. Dwarf growth, general xerophily and the predominance of mosses and lichens are noteworthy features of the tundra. The type of vegetation determines the peculiarity of the tundra. Thus we have, as characteristic plant associations, a moss a Polytrichum tundra, a Lichen tundra, and the facies is conditioned by the climatic conditions which control, whether we have a Cladonia tundra (*Cladonia rangiferina*, *Sphaerophoron coralloides*), a Platysma tundra (*Platysma cucullatum*, *Cetraria islandica* etc.) or an Alectoria heathery. Where the climatic

1) OSGOOD, WILFRED H.: Results of a biological Reconnaissance of the Yukon River Region. North American Fauna No. 19. U. S. Division Biological Survey 1900.

**Arctic Tundra**

near the Arctic Ocean in the valley of the Colville River, northern Alaska 70° N. Lat. 151° W. Long., at an altitude of 100 feet 30 m
Photograph reproduced by permission United States Geological Survey.

conditions are unusually severe the vegetation forms a scant covering to the stony earth the socalled Rock tundra. Level depressions in the tundra which collect the melted snow water are swampy places like moors where a scanty turf consists of sphagnum with small phanerogamic species *Empetrum nigrum*, *Ledum groenlandicum* (= *L. latifolium*), *Betula glandulosa*, *B. nana*, *Menyanthes trifoliata*, while on gravelly ridges in the Hudson Bay region grow *Salix anglorum*, *S. phylicifolia*, none of them exceeding a few inches in height.

## b) Marine Algal Formation.

A thorough study of the distribution of the marine Algae of the Arctic Sea has led KJELLMAN to the position that the marine vegetation of Baffin Bay to which the flora of the Canadian Arctic Sea seems to approach nearly is extremely isolated. It possesses a considerable number of elements wanting in the rest of the arctic flora; its characteristic species are partly different and one of them belongs to a generic type that is not represented at all in the floras of the other arctic marine phytogeographic provinces. The character of the marine vegetation in the American province is chiefly marked by *Fucus vesiculosus*, *Agarum Turneri*, *Laminaria longicruris*, *L. atrofulva*, *L. cuneifolia*, *Alaria*.

Within the American province according to KJELLMAN [1] the following species may be regarded as the most abundant ones:

Lithothamnion glaciale Kjellm.
» polymorphum L.
Polysiphonia urceolata Lightf.
Rhodophyllis dichotoma Lepech.
Rhodomenia pertusa Post et Rupr.
» palmata L.
Ptilota pectinata Gunn.
» plumosa L.
Diploderma miniatum Ag.
Fucus vesiculosus L.
» filiformis Gmel.
Agarum Turneri Post et Rupr.
Laminaria longicruris De la Pyl.
» atrofulva J. G. Ag.
» cuneifolia J. G. Ag.
Chorda filum L.
Desmarestia aculeata L.
Dichloria viridis Mull.
Dictyosiphon foeniculaceus Huds.
Enteromorpha compressa L.
Monostroma fuscum Post et Rupr.
» Blyttii Aresch.
Diplonema percursum Ag.
Spongomorpha arcta Dillw.
Cladophora rupestris L.
Rhizoclonium pachydermum Kjellm.
Chaetomorpha Wormskioldii Fl. Dan.
» melagonium Web et Mohr.
Urospora penicilliformis Roth.
Rivularia hemisphaerica L.

## c) Formations of the Pribilof islands.

The Pribilof group of Islands (St. Paul, St. George and two islets) is about 350 kilometers (220 miles) north of the Aleutian chain and is of volcanic origin. The highest land is on St. George where a precipitous cliff fronting the sea

1) The Algae of the Arctic Sea. Kongl. Svenska Vetenskaps-Akademiens Handlingar Bandet 20, No. 5. Stockholm 1883: 78.

and a hill in the interior exceed 275 meters (900 feet). The highest land in St. Paul is 183 meters (600 feet). In summer the islands are almost constantly enveloped in fog.

*Dune formation.* The sandy shores and dunes of these islands show a sparse vegetation. *Cochlearia officinalis, Alsine (Arenaria, Ammodenia) peploides* and *Elymus mollis* are the characteristic plants. *Lathyrus maritimus* and *Mertensia maritima* also occur. There is not a tree or bush on either island, but a dwarf willow creeping prostrate on the ground for a length of eight or ten feet called talneek by the natives is the largest woody species, hardly growing three inches in the moss-bed in which it is found. Two other species of willow occur: *Salix polaris* and *arctica*. Many of the side hills and flats are buried waist deep in a dense growth of *Elymus mollis, Heracleum lanatum*. Growing on the cliffs are *Draba hirta, D. (Nesodraba) grandis, Arabis petraea (= ambigua), Sagina Linnaei (= S. saginoides), Saxifraga bracteata, S. davurica* and *serpyllifolia* with *Chrysosplenium Beringianum* and *Gentiana glauca, Lychnis apetala* in the higher parts.

*Lake Formation.* The ponds and lakes are surrounded by mud flats on which a number of species not found elsewhere grow, viz., *Chrysanthemum arcticum, Stellaria (Alsine) humifusa, Potentilla anserina, Montia fontana, Ranunculus reptans, R. hyperboreus.*

*Bog Formation.* The number of plants confined to bogs and old marshes is small. On the bogs are found *Rubus chamaemorus, Saxifraga hirculus, Pedicularis sudetica*, while on one bank of a little pond in St. Paul Island were found *Coptis trifolia, Geranium erianthum, Arnica unalaschensis, Veronica Stelleri, Petasites frigida.* The moss and heather bogs according to MERRIAM [1]) are blue from the abundance of *Campanula lasiocarpa* associated with *C. pilosa* (an inconspicuous species), *Geum (Sieversia) Rossii* with yellow flowers, *Viola Langsdorfii, Gentiana frigida* with white and blue flowers, *Claytonia arctica, Cornus unalaskensis* and *Trientalis arctica.* [2]-[3]) Level areas of considerable extent with soil saturated with water are covered with mosses, *Hypnum, Racomitrium*, little *Sphagnum.*

*Elevated Insular Formation.* The commonest plants on the wind blown and elevated parts of the islands are *Eritrichium Chamissonis, Silene acaulis, Arenaria macrocarpa, Eutrema Edwardsii, Papaver radicatum (= P. nudicaule), Potentilla villosa, Artemisia globularia, Pedicularis Langsdorfii* and *lanata.* The raspberries are represented by two dwarf species *Rubus stellatus* and *R. chamaemorus*, while *Empetrum* as a heather plant abounds on both islands.

*Upland Meadow Formation.* The vegetation of grassy banks and upland meadows generally near the sea consists of *Ranunculus nivalis (= R. altaicus)*,

1) Plants of the Pribilof Islands. 1892.

2) JORDAN, DAVID STARR: The fur seals and fur-seal Islands of the north Pacific Ocean. 1899. Part III plants by James Macoun, p. 559—587.

3) ELLIOTT, HENRY W.: A Monograph of the seal Islands of Alaska. U. S. Fish. Com. Bulletin (Special) 176. 1882: 138.

*R. Eschscholtzii*, *Valeriana capitata*, *Taraxacum lividum*, *Pedicularis verticillata*. Damp sheltered places among the rocks in the interior of St. Paul Island show a growth of *Claytonia sarmentosa*, *Viola Langsdorfii*, *Gentiana frigida*. Ferns are scarce, but species of *Equisetum* (3), *Botrychium* (1), *Phegopteris* (1), *Aspidium* (2), *Asplenium* (1), *Cystopteris* (1), and *Lycopodium* (3) occur.

Fungi on the Pribilof islands are abundant and varied, especially in and around the vicinity of the rookeries and killing grounds of the seals.

*Marine Algal Formation.* The algae of these islands are noteworthy both in extent and luxuriance. After the heavier gales, the beach will be found covered with a vast windrow of kelp and seaweed heaped several feet high with the Phaeophyceae most abundant, as *Laminaria longipes*, *Agarum Turneri*, *Thalassiophyllum clathrus*, *Nereocystis Luetkeana*, *Alaria praelonga* and *Fucus platycarpus*. The Chlorophyceae and the Rhodophyceae comprise many genera, f. e. *Lithophyllum*, *Lithothamnion*, *Porphyra*, *Chondrus*, *Gymnogongrus*, *Callophyllis*, *Rhodophyllis*, *Ptilota* (3 spec.), *Odonthalia*, *Rhodomela*, *Nitophyllum* and *Delessaria*, *Constantinea rosa marina*.

## 2. Sub-Arctic Forest Region of North Canada and Alaska.

The subarctic zone is situated south of the arctic tundras and has its northern limit in the line representing the northern extension of tree growth. Its southern boundary is somewhat indefinite, but may be considered in general as corresponding with the southern limit of the great northern coniferous forest which stretches across the continent, reaching the Pacific Ocean in southwestern Alaska. For convenience and because the division is a natural one, four districts are recognizable, viz., the Labrador, Hudson Bay, Mackenzie and Alaskan districts. These territories are denominated phytogeographically speaking districts, because the flora is hardly sufficiently distinct in each to merit the use of the proper term *region* which should be used to distinguish areas of the earth's surface sharply demarcated botanically speaking.

### A. Labrador District.

*Trees and shrubs.* The southern half of the Labrador District is included in the subarctic forest belt and four coniferous trees may be classed, as forming the Sub-Arctic Coniferous Formation: *Pinus Banksiana* (= *P. divaricata*), *Picea alba* (= *P. canadensis*), *Picea nigra* (= *P. mariana*), *Larix americana* (= *L. laricina*). With these species are associated *Betula papyrifera*, *Populus tremuloides*, *P. balsamifera* and in less abundance and of more circumscribed range *Abies balsamea* and on the southeastern margin *Thuja occidentalis*.[1-2] The distribution of the forest and the range of its trees depends

1) Macoun, John: The Forests of Canada. Transactions Royal Society Canada XII. 1894. sect. IV: 3—20. (cfr. Bibliography, p. 55.)

2) Low, A. P.: Report on Explorations in the Labrador Peninsula Geological Survey of Canada. Report L 1896: 30—39. (cfr. Bibliography, p. 54.)

on the latitude or height above sea-level, distance from sea-coast and the character of the soil. The forest is continuous in the southern part of Labrador, the only exceptions being the summits of rocky hills and the outer islands of the Atlantic coast. North of latitude 53°, the higher hills are treeless and the size and number of the barren areas (Barren Formation) increase rapidly, until in latitude 55°, the trees are confined to the margins of small lakes and in the valleys of the rivers. Leaf River, which empties into Ungava Bay, is the northern limit of forest trees on the west side of the Bay, and a line from that river to the mouth of Nastapoka River would represent a close approximation to the northern limit of trees in western Labrador. The barren grounds on the east coast at Davis Inlet (56°) are confined to the headlands and islands which remain treeless to the south of Hamilton Inlet, while about the heads of the larger bays and on the lowlands of the small river valleys, the country is well timbered. *Pinus Banksiana* prefers the dry sandy drift ridges and rocky hills, where it is often found along with the black spruce *Picea nigra*. It occurs abundantly inland and reaches its northern limit on the south branch of the great Whale River. Longitude 71° W. seems to mark its eastern limit. The distribution of *Picea alba* depends on the soil, occupying the areas of re-arranged drift of the river-valleys and marine deposits along the coast, or to the heavier drift of the interior, but as an element of the forest except in the Hamilton River valley, it is never important.

*Picea nigra* on the other hand is the most abundant tree of Labrador and constitutes over ninety per cent of the forest (Picea nigra-Facies). It grows freely on the sandy soil which covers the great Archaean areas, and thrives as well on the dry hills, as in the wet swampy ground between the ridges. The growth is thick everywhere on the southern watershed, while at its northern limit, which is the limit of tree growth, it develops large branches and with the larch is the last tree encountered before entering the barren grounds or tundra. *Abies balsamea* is found nearly to the edge of the tundra and throughout the forest it grows more or less plentifully about the margins of the larger lakes and banks of the rivers (Abies balsamea-Facies), preferring moist alluvial soil, while the larch *Larix americana* everywhere in Labrador is found growing in the cold swamps (Larix americana-Facies). It continues as a tree to the northern margin of the forest, where *Picea nigra* becomes a shrub.

The range of *Populus tremuloides* depends to a great extent on the nature of the soil and in the western half of the peninsula the tree is most abundant where it grows on the unmodified glacial till of the drift ridges. Cape Jones on the Hudson Bay coast is the northern limit of the aspen, while inland it is found at latitude 54°. The balsam poplar, *P. balsamifera*, extends farther south than the aspen and it confines itself to the heavy clay soil of the river-valleys, or to the modified drift of the Cambrian areas. *Betula papyrifera* is found everywhere throughout the southern portion of the peninsula, while *Thuja occidentalis* hardly enters the peninsula, about the foot of James Bay and Mistassini Lake.

Throughout the forest, the lowlands fringing the streams are covered with thickets of *Salix* (Salix-Facies): *S. adenophylla*, *balsamifera*, *chlorophylla*, *Ribes prostratum* and *Alnus*. The areas covered by these shrubs increase toward the tundra and they not only margin the rivers and shores of the lakes but with dwarf birches occupy much of the open glades, and on the sides of the hills above tree line the willow and birches form low thickets exceedingly difficult to penetrate.

The undergrowth of the forest consists of *Ledum latifolium* and *Kalmia glauca* which grow in tangled masses two to four feet high, while *Prunus pennsylvanica* occurs but more frequently in the burned areas whither its drupes are carried by birds. *Rubus chamaemorus* occurs in swamps everywhere and beyond tree limit. *Rubus arcticus* grows in the opens along the banks of northern streams and is especially abundant on the islands along the east coast of Hudson Bay. *Rubus triflorus* (= *R. americanus*) occurs along the banks of streams and on the edge of woods northward from the St. Lawrence. *Rubus strigosus*, *Fragaria virginiana*, *Amelanchier canadensis* occur in Labrador, the latter in glades occupying swampy ground. Several species of *Vaccinium* are found abundantly throughout the peninsula viz., *V. pennsylvanicum*, *V. uliginosum* growing in open spaces in the north, occurring as a spreading shrub in the barren grounds, *V. caespitosum*, a more northern species than the last, found on the summits of the higher hills about the headwaters of the Hamilton River. *V. Vitis-Idaea* grows abundantly in open barren spaces, while south of latitude 51° it occurs on the summits of barren rocky hills, on or barren islands in the larger lakes. *Empetrum nigrum* is abundant throughout the semi-barren and tundra areas of Labrador, where it grows on the coast and inland. Altogether the number of flowering plants and ferns found in Labrador comprises some 568 species and varieties [1]). *Chiogenes hispidula*, the snowberry, grows in mats on the ground in damp shady woods.

*Moor Formation.* The moors of Labrador are characterized by *Salix myrtilloides*, *Betula nana*, *Lonicera coerulea*, *Lyonia* (*Cassandra*, *Chamaedaphne*) *calyculata*, *Kalmia glauca* and *angustifolia*, *Ledum palustre* and farther south in Labrador *L. latifolium*.

Rhododendron Rhodora (= Rhodora canadensis), Andromeda polifolia, Vaccinium oxycoccus and macrocarpum, Arctous (Mairania) alpina and Comandra livida occur as important elements of the moor flora. *Rubus arcticus, Cornus suecica and Pyrola rotundifolia inhabit sandy* situations transitional to the forest. The sphagnum cushions which form such a prominent feature of the Labrador moors are surrounded by such plants as Empetrum nigrum, Drosera rotundifolia, Potentilla palustris, Parnassia palustris, Saxifraga hirculus, Sagina (Spergula) nodosa, Montia fontana, Pinguicula vulgaris, P. alpina, Bartsia alpina, Tofieldia palustris, Scheuchzeria palustris, Eriophorum alpinum, E. vaginatum, E. capitatum (= E. Scheuchzeri), E. latifolium, E. gracile, Carex echinata, C. magellanica, C. sparsiflora, C. canescens and Equisetum scirpoides [2]).

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1) Macoun, James M.: List of Plants known to occur on the Coast and in the Interior of the Labrador Peninsula. Annual Report Geological Survey Canada new ser. VIII. 1895. Appendix VI.

2) Engler, A.: Die pflanzengeographische Gliederung Nordamerikas: 7—8.

The colors of the vegetation are due to the omnipresent *Ledum* together with the somewhat less universal *Loiseleuria* and *Bryanthus*. In the autumn the red leaves of *Arctous* are the most attractive of the season's colorings. The bake-apple, *Rubus chamaemorus*, its single white flowers associated with the rose colored flowers of *Rubus arcticus* are frequently seen. *Cornus canadensis* grown in thick groups, and dense tufts of the white flowered *Diapensia lapponica* and moss pink *Silene acaulis* are common.

Astragalus alpinus, Oxytropis (Aragallus) podocarpa, O. (Aragallus) campestris var. caerulea, Pinguicula vulgaris, P. villosa, P. alpina and many inconspicuous Cruciferae and Caryophyllaceae complete the list of forms more universally present in the early part of the season [1]. Solidago Virga-aurea, S. macrophylla, Epilobium (several species), Lychnis alpina, Arnica alpina, Campanula rotundifolia, Linnaea borealis are prominent in summer, while Papaver nudicaule is not unfrequent on hill tops.

*Sea Cliff Formation.* The sea coast of Newfoundland presents an irregular line of cliffs, beaches and headlands on which are *Alnus viridis* (= *A. alnobetula*), *Viburnum pauciflorum*, *Cornus stolonifera*, *Ribes prostratum*, *Empetrum nigrum*, various species of *Rubus* and *Vaccinium*.

*Strand Formation.* The seashore in Labrador supports Arenaria (Ammodenia) peploides, Mertensia maritima, Potentilla anserina, P. (Sibbaldiopsis) tridentata, Archangelica (Angelica) atropurpurea, A. Gmelini, Plantago maritima, while Lathyrus maritimus is abundant. The strand flora of Newfoundland consists of Plantago maritima, Ligusticum scoticum, Arenaria (Ammodenia) peploides, Mertensia maritima, Cakile americana (= C. edentula), Salicornia herbacea, Lathyrus maritimus, Atriplex hastata, Ranunculus (Oxygraphis) cymbalaria, Moehringia (Arenaria) lateriflora, Primula mistassinica, while the waves roll in tangled masses of Vallisneria spiralis, Fucus vesiculosus, Laminaria.

*Coniferous Forest Formation of Newfoundland.* Here the trees are chiefly *Abies balsamea*, *Picea nigra*, *Picea alba*, with a moderate mixture of *Pinus strobus*, *Betula papyrifera* and *Populus tremuloides*. The trees are usually stunted on the headlands and points of land jutting into the sea, while the higher ground inland may bei covered with bushes of *Juniperus communis*, *Taxus canadensis*, *Lyonia* (*Chamaedaphne*) *calyculata* (Juniperus-Taxus Association).

"Juniperus communis, under either its common or alpine form, is found from the bleak rocks of Labrador to the coast of the Pacific. At one time on an exposed shore, at another on a mountain top, beside the cataract, and again on the shore of a lonely lake, it greets the wanderer wherever he may be, and yet it is nowhere abundant" [2].

Remarkable herbaceous plants of the forest are: Streptopus roseus, Trillium recurvatum, Listera convallarioides, Goodyera (Peramium) pubescens, Smilacina (Vagnera) stellata, Coptis trifolia, Aralia nudicaulis. — Secondary woody species: Prunus pennsylvanica, Nemopanthes canadensis (= fascicularis, Ilicioides mucronata), Viburnum lentago, V. acerifolium.

In drier woods Mitchella repens, Epigaea repens occur. The edge of the forest along rocky hills is fringed with Juniperus virginiana var. humilis. Arctostaphylos uva-ursi, Vaccinium uligi-

1) Delabarre, E. B.: Report of the Brown-Harvard Expedition to Labrador: Bulletin Geographical Society of Philadelphia III, No. 4. April 1902.

2) Macoun, Catal. Canadian pl. I, 462. Very remarkable for this single Coniferous plant common with Europe, and of the same distribution as Alnus viridis! (Drude.)

nosum, Loiseleuria procumbens, Potentilla (Sibbaldiopsis) tridentata, cover the open rocky situations, while on the top of rocks (Rock Boulder Plant Association) the lichens Cladonia rangiferina and Cetraria islandica, are abundant; in the fissures of cliffs Dryopteris (Aspidium) fragrans. Occasionally woods of Betula lutea (Betula lutea Facies) are found in Newfoundland, and here the botanist finds Pyrola rotundifolia, Monotropa uniflora, Lycopodium dendroideum (= L. obscurum), L. lucidulum, L. clavatum, L. complanatum, and L. alpinum.

*Bog Plant Formation.* The bogs are open areas, or barrens, and represent converted glacial lakes surrounded by stunted spruce and broken by deep circular ponds of brown water in which grow *Menyanthes trifoliata.* The sphagnum-bogs surrounding such ponds contain *Eriophorum vaginatum*, *virginicum* and *latifolium*, *Arethusa bulbosa*, *Sarracenia purpurea*, while on the surface spreads *Rubus chamaemorus.* Such boggy areas are fringed with *Pirus arbutifolia*, *Myrica gale*, *Andromeda polifolia*, *Lonicera caerulea*, *Empetrum nigrum*, and *Larix americana.*

*Marsh Formation.* The marshes are characterized by *Caltha palustris*, *Osmunda cinnamomea*, *Asplenium thelypteroides*, *Mentha canadensis* in tufts beside the pools, while in muddy places which seem iron-stained occurs *Drosera rotundifolia.*

Vaccinium oxycoccus, Rubus triflorus, Kalmia angustifolia and glauca, Ledum latifolium, occur in such marshy places with clumps of Alnus incana, Rhododendron rhodora (= Rhodora canadensis) and on moss covered stumps Chiogenes hispidula. Hillocks outside the swamps support Cornus canadensis. Near such swamps in the drier ground are found Sorbus americana, Amelanchier canadensis, Acer rubrum, Acer spicatum, with tangles of Rubus strigosus, Pteris aquilina. On the sandy shore of brooks grow Salix petiolaris, Sagina procumbens and Senecio vulgaris, while Triodia (Sieglingia) decumbens, Nardus stricta also occur in such situations. [1–3]

## B. Hudson Bay-Keewatin District.

The country between Lake Winnepeg and Hudson Bay which forms part of the Hudson Bay District consists largely of swamps, mainly grown up to willows and tamaracks.

*Lake Formation.* The shallower lakes are characterized by extensive patches of *Scirpus lacustris*, *Myriophyllum*, *Potamogeton*, *Calla palustris*, *Acorus calamus*; *Nuphar (Nymphaea) advena* also occurs. However, there are numerous elevated places, rocky "islands" on which has accumulated a rather thin covering of soil supporting a moderately heavy timber growth of *Picea nigra*, *P. alba*, *Abies balsamea*, *Pinus Banksiana*, *Populus tremuloides* and *balsamifera*, *Betula papyrifera* and *Larix americana.* These species form the bulk of the forest in the district.

*River Bank Formation.* The river banks are covered with a rank growth of willows and grasses amid which are various orchids, violets and polygonums.

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1) Bell, John: in Canadian Naturalist new ser. IV; cfr. Bibliography, p. 51.

2) Robinson, B. L. and v. Schrenk, H.: Notes upon the Flora of Newfoundland. Canadian Record of Science. VII: 3—31.

3) Macoun, Prof.: List of Plants collected in Newfoundland in 1885. Report DD 1885, new ser. Geological and Nat. Hist. Survey of Canada. Appendix I.

Several species of *Equisetum* grow abundantly in the shallow water and often on the banks of streams *Rhamnus alnifolia*, *Lonicera glaucescens*, *Elaeagnus argentea*, *Viburnum pauciflorum*, *Shepherdia* (*Lepargyraea*) *canadensis* occur. *Pinus Banksiana* and *Betula papyrifera* reach their northern limit near the confluence of Hill and Fox rivers; as also the aspen *Populus tremuloides*.

*Swamp Formation.* Back from the rivers are mossy swamps in which the vegetal growth consists of *Empetrum*, *Ledum latifolium*, *Betula glandulosa* and associated species[1].

## C. Mackenzie District.

The southern boundary of the subarctic forest of the Mackenzie District is marked by the northern extension of the prairies. It runs, as follows: From near the junction of the north and south forks of the Saskatchewan River, it passes southeasterly by the sources of the Red Deer and Assiniboine, and over the southwestern slopes of Duck and Riding mountains to the south end of lakes Manitoba and Winnepeg.

*Coniferous Forest Formation.* The shores of the Athabasca River are covered, according to EDWARD A. PREBLE[2], with a fair growth of black and white spruces (*Picea nigra* = *mariana* and *P. alba* = *canadensis*), Banksian pine, balsam (*Abies balsamea*), tamarack (*Larix americana*), balsam poplar (*Populus balsamifera*), aspen (*P. tremuloides*) and canoe birch (*Betula papyrifera*). Of these species *Pinus Banksiana* and *Larix americana* are the least abundant, the former growing only on certain elevated points, and the latter being a tree of the sphagnum bogs, rarely appears on the immediate banks of the river.

Various shrubs are found and form an undergrowth in the forest. Such are Juniperus nana, J. sabina, various species of willows (Salix Bebbiana etc.). Alnus incana, A. viridis (= A. alnobetula), Ribes rubrum, R. oxyacanthoides, Rosa acicularis, Amelanchier alnifolia, Shepherdia canadensis, Elaeagnus argentea, Cornus stolonifera, C. canadensis, Prunus pennsylvanica, Viburnum pauciflorum, V. opulus, Lonicera glaucescens, L. involucrata, Symphoricarpus racemosa and occidentalis.

The country at the outlet of Great Bear Lake is undulating and, except for certain semibarren places near the shores of the lake, is well wooded with *Picea*, *Larix*, and the usual subarctic vegetation. Much of the ground is covered with lichens of the genus *Gyrophora* and various mosses. On September 16th, PREBLE noticed that the leaves of the larches and other deciduous trees were falling. Elsewhere along the Mackenzie River, the forests of *Picea nigra* (*mariana*) and *P. alba* (*canadensis*) are filled with an undergrowth consisting of *Rosa acicularis*, *Rubus strigosus*, *Viburnum pauciflorum*, *Vaccinium uliginosum*, *Ribes rubrum* and *prostratum*. As the northern limit of trees is reached,

1) PREBLE, EDWARD A.: A biological Investigation of the Hudson Bay Region. North American Fauna No. 22: 1902.

2) A Biological Investigation of the Athabasca-Mackenzie Region. North American Fauna No. 27, 86: 1908.

the specimens of spruce and larch become much dwarfed, twisted and wind swept, but this condition is reached farther south in exposed locations along the shores of the numerous lakes that such plants as *Salix phlebophylla* = *anglorum* cling to the rocks and *Vaccinium uliginosum*, as well, as *Juniperus Sabina* var. *procumbens* assume a typical dwarf habit. The islands in Great Slave Lake are wind swept and their vegetation becomes stunted and dwarf, so as to remind one of that existing at the northern tree limit.

Forests exist, on the mountains which parallel the western bank of the Mackenzie River, where it joins the Nahanni River in latitude 62° 15′ N. Here at the apex of the confluence rises a mountain 2,500 feet (760 m). Its northern face is steep and terraced. The slopes are as well wooded as the nature of the soil will allow, the common trees ascending together with *Salix alaxensis* and *phlebophylla* to 2,000 feet, and occuring at their upper limit as depauperate shrubs.

*The extreme summit of the Nahanni Mountains is tenanted by* Salix myrtillifolia, S. alaxensis, Dryas integrifolia, D. Drummondii, Pedicularis euphrasioides, Pinguicula vulgaris, Anemone Richardsoni.

*Aspen Forest.* Lying between the coniferous forest proper and the prairie is a belt of aspen, Populus tremuloides, which extends from the international boundary in latitude 49° all around the prairie region in the north. It penetrates the prairie region, and northward it enters the coniferous forest, whereever there is good dry soil, and is the bulk of the forest in the Peace River country and on the plains lying along the Liard and the Mackenzie rivers. It keeps out of the flood plains of the river valleys in its northwestern home and never appears on islands or on alluvium at any time.

The balsam poplar on the other hand makes its home on the river bottoms and islands and is seldom found anywhere else. (Populus balsamifera-Facies.) It grows to immense size on the Peace, Athabasca, Liard, Slave and Mackenzie rivers, where it is not uncommon to see trees over six feet in diameter. It is this species and the white spruce that are found as driftwood on the shores of the Arctic Sea, as *Picea alba* and *Populus balsamifera* constitute the trees of the islands and flood plains of the Mackenzie and its tributaries, which are constantly changing and being re-formed by the spring freshets. Spruce grows on the larger islands, especially at the upper end before erosion takes place, crowding out the old poplars, for spruce trees are never found on a new island where poplars abound in all stages from trees four feet in diameter to seedlings growing in the mud recently deposited at the lower end of the islands.

The moist soil and river plants in the mud along the Athabasca River are Potamogeton pectinatus, P. natans, P. praelongus, P. perfoliatus, while *Salix longifolia, S. nigra, S. discolor* form an edging to the stream associated with Carex utriculata, C. aquatilis, Scirpus silvaticus, Typha latifolia, Acorus calamus, Caltha natans, Petasites (Nardosmia) sagittata, Sparganium simplex and eurycarpum.

*Lake Formation.* The islands in the northern arm of Great Slave Lake show many lakelets and swamps in which, as well, as about the low shores

of the northern arm of the lake grow *Menyanthes trifoliata*, *Parnassia palustris*, *Calla palustris*, with sedges and grasses. In a small pond on one of the Simpson islands is found a colony of *Nymphaea (Castalia) tetragona* (growing only in a few other stations in North America). The southern shore of Great Bear Lake is characterized by the presence of *Salix alaxensis*, *S. glaucops*, *S. reticulata*, *Vaccinium uliginosum* and *Myrica gale*.

*Bog Formation.* The bog plants of this district are the common *Rubus chamaemorus*, *Vaccinium canadense*, *V. vitis-idaea*, *Ledum latifolium*, *Betula pumila*, and several species of *Salix*.

Back of Fort Norman the muskegs are filled by shrubby growth of Lyonia (Chamaedaphne) calyculata, Andromeda polifolia, Ledum latifolium and L. palustre, Vaccinium uliginosum, while in other muskegs of the region occur in addition Salix myrtilloides, Rubus chamaemorus, Empetrum nigrum, Kalmia glauca.

*Prairie and River Bank Formation.* Along the Peace River in the southwest of this district the slopes of the hills are very warm, being inclined toward the sun at a considerable angle and on these the greater number of prairie species by whose presence this district separates itself from those in the east are found, viz., *Opuntia missouriensis* and others. The common Rocky mountain pine *P. Murrayana* enters the district from the south where it meets from the east *Pinus Banksiana* and *Larix americana*, which forms the so called tamarack swamps.

*Shepherdia canadensis* occurs on rocky declivities and boulder strewn banks, while *Elaeagnus argentea* occupies sandy situations. *Salix candida*, *Lactuca pulchella*, *Heuchera hispida* inhabit damp stream banks and *Geum triflorum* with *Woodsia ilvensis* on rocks.

All the country south of Great Bear Lake almost as far east as the Coppermine River is fairly well wooded and abounds in lakes[1]). North of the lakes the tundra prevails.

## D. Alaska District.

The only change that takes place in the sub-arctic forest when the northern Rocky Mountains are reached in Alaska, north of 53°, is the substitution of *Pinus Murrayana* (= *P. contorta* var. *Murrayana*) for *P. Banksiana* and *Abies subalpina* (= *A. lasiocarpa*) for *A. balsamea* which was left far to the east; otherwise the same forest extends from Labrador to the tundra of Alaska and to the Pacific coast in the neighborhood of Cook Inlet. The separation of the coast Pacific flora from that of the interior with which we are here concerned, is in general complete.

*Sub-arctic Coniferous Forest Formation.* The character of the interior of Alaska is far from well known. We known that *Picea alba* is here the most important species (Picea alba-Facies) and it attains a considerable size north

1) Bell, J. Macintosh: Explorations in the Great Bear Lake Region. Geographical Journal XVIII: 258. September 1901.

of the 56° N.L., forming in the valley of the Yukon forests of no little importance. *Betula papyrifera*, *Populus balsamifera*, *Pinus Murrayana* and *Abies subalpina* occur here (Betula-Populus-Facies). The larch *Larix americana* is known from only one locality in Alaska, Fort Gibbon, mouth of the Tanana River.

In these woods are found Botrychium virginianum, Nephrodium spinulosum and dryopteris (on stony soil), Polypodium vulgare, Pellaea (Cryptogramme) Stelleri, Cryptogramme acrostichoides (between stones), Pteridium aquilinum, Cystopteris fragilis, Streptopus roseus, Linnaea borealis, Cornus canadensis, Arabis Holboellii, Lathyrus ochroleucus, Arctostaphylus uva-ursi and Vaccinium vitis-idaea. From the accounts of explorers the interior appears to be an open plateau devoid of trees with scattered open groves on the lower hill slopes and ridges. Trees usually crowd the banks of rivers and lakes covering many of the river islands with dense thickets.

On the headquarters of the Yukon about Pelly River the mountains, a short distance from the river, are covered with a heavier growth of spruce, while the *Populus balsamifera*, *Alnus incana* and *viridis* with *Salix cordata*, *Viburnum*, *Cornus*, *Ribes*, *Rosa nutkana*, *Spiraea salicifolia* and *Potentilla fruticosa* line the river banks and the birches are scattered. The exposed hillsides are covered with boreal sage brush (*Artemisia frigida*) with here and there a prostrate juniper, or a small clump of spruces, terminating here the Artemisia frigida-Formation. The Yukon widens after it receives the waters of the Big and Little Salmon rivers. The rolling hills are sometimes a mile or several miles from the river bank with low willow swamps between.

*Alluvial Island Formation.* Islands in the river, however, are covered with a luxuriant vegetation. Alders generally form the outer strip; next come the willows; next the poplars, rising somewhat higher; and finally the dark-green spruces which occupy the central area. As undergrowth occur plants of the genera *Cornus*, *Viburnum*, *Rosa*, *Ledum*, *Vaccinium*, *Ribes* and *Shepherdia*. *Pinus Murrayana* occurs though not forming a continuous forest and it disappears entirely beyond Fort Selkirk.

After leaving the junction of the Pelly River the poplars of the forest increase over the spruces not only in number but in size, while the birches hold their own and *Pinus Murrayana* is entirely absent (Populus-Facies). Finally *Picea alba* becomes dwarfed and entirely subordinate to the poplars which form a dense forest crown for miles. The spruces occupy the gulches and occur as small clumps elsewhere. The undergrowth remains the same, and deep moss covers the ground and rocks. *Juniperus nana*, *J. sibirica* is found occasionally on hillsides and in more open hilly places the landscape is brightened by *Epilobium* (*Chamaenerion*) *angustifolium*. The sandy islands of the lower Yukon River are covered with impenetrable thickets of willow, while the hills are covered with poplars, alders and birches in dense thickets with scattered spruces. A few of the remarkable plants of the Yukon basin i. e. of the Matanniska River and affluents are:

Anemone narcissiflora L.
parviflora L.
Aconitum delphinifolium DC.
Arabis lyrata L.

Viola glabella Nutt.
Geranium erianthum DC.
Lupinus nootkatensis Don.
Astragalus alpinus L.
Oxytropis Lambertii var. sericea Nutt.
Hedysarum Mackenzii Rich.
Potentilla nana Willd.
Poterium (Sanguisorba) canadense Gray.
Rosa nutkana Presl.
Sedum Rhodiola DC.
Cornus suecica L.
Viburnum pauciflorum Pyl.
Arnica latifolia Bonz.
Ledum latifolium Ait.
» palustre L.
Pirola uniflora L.
» rotundifolia L.
Trientalis arctica Fisch.
Mertensia paniculata Don.
Pedicularis sudetica Willd.
Boschniakia glabra C. A. Mey.
Pinguicula villosa L.
Rumex occidentalis Wats.
Streptopus amplexicaulis DC.

## Chapter II. North American Temperate Zone: Atlantic Section.

The temperate zone is meant to include that part of the continent which does not have a decidedly rigorous climate, and which does not have a sufficient amount of heat to be considered as of torrid climate. The word is here used in its physical zone sense, because it affords a convenient means of classifying the phytogeographic sections and regions of our country in a broad and general manner. Approximately the temperate zone of North America may be considered to lie between the isothermal lines of 40° and 70° Fahrenheit (4,4°—21,1° C) the latter representing the boundary of the physical torrid zone. Three sections of this zone are recognizable: the Atlantic, the Pacific and the Mexican.

*Atlantic Section.* The Atlantic Section (or Province) of the North American Temperate Zone comprises in the main the territory of North America which is drained into the Atlantic Ocean. Three subdivisions are to be noted, viz., the coastal, the mountainous and the plain. The treatment of the several phytogeographic regions of the coastal portion of the Atlantic Section will now be considered categorically. It must be understood that the regions, districts, areas, formations form the natural phytogeographic entities, while the classification into zones, sections etc. has been purely arbitrary to assist in demarcating the geographic location of the regions now briefly to be considered.

### 1. St. Lawrence — Great Lake Region.

As the name indicates this region occupies the valley of the St. Lawrence River and the basin of the Great lakes for some distance on either side of these natural waterways. In the main, the flora is a homogeneous one with the White pine *Pinus strobus*, *P. resinosa*, *Acer saccharum* (= *A. saccharinum*), *Acer pennsylvanicum*, *Sorbus americana*, *Betula lenta* and *B. lutea* as prominent

elements in it. These species range elsewhere but nowhere form such pure growths as in this region. The comparatively few broad-leaved species is also a noteworthy characteristic. — Two districts of this region may be distinguished: the maritime and the lake districts.

## A. Maritime District.

This district comprises practically all of the country south of the subarctic forest, as far, as Narraghansett Bay and northern Connecticut. Its eastern boundary is the Gulf of St. Lawrence and the Atlantic Ocean, while its western may be set approximately at hake Champlain and the Ottawa River. It possesses in its flora such plants as occur on the coast and in Salt marshes, etc., which the inland district does not have.

### a) New Brunswick Area.

This area territorially covers Nova Scotia, New Brunswick and that portion of Quebec south of the subarctic forest (see page 351). It comprises the Laurentian highlands south of 50° N. L. The northern portions of Maine, New Hampshire and Vermont (including their mountain ranges) are part of this area, its southern boundary being determined by the southern limit of *Pinus Banksiana* (= *P. divaricata*), *Picea alba* (= *P. canadensis*), as well, as the northern limit of the tulip poplar, *Liriodendron tulipifera*.

1. The Forest-formations of northeastern Temperate North America.

The original forests of Prince Edward Island conform essentially to those of Nova Scotia and New Brunswick, as regards species, but their distribution is different. The trees indigenous to the island are the following:

Acer saccharum Marsh. (= A. saccharinum Wang.).
» rubrum L.
» pennsylvanicum L.
Prunus serotina Ehrh.
» pennsylvanica L. f.
Fraxinus nigra Marsh. (= F. sambucifolia Lam.).
» americana L.
Ulmus americana L.
Betula papyrifera Marsh.
populifolia Marsh. (= B. alba var. populifolia Spach).
lutea Michx. f.
Fagus americana Sweet (= F. ferruginea Ait. = F. grandifolia Ehrh.).
Quercus rubra L.
Populus tremuloides Michx.
» balsamifera L.
Pinus strobus L.
» resinosa Ait.
Picea alba Link (= P. canadensis B.S.P.).
» nigra Link (= P. mariana B.S.P.).
» rubra Lam. (= P. rubens Sarg.).
Abies balsamea Mill.
Tsuga canadensis Carr.
Larix americana Michx. (= L. laricina [Du Roi).
Thuja occidentalis L.

Sugar maples and beeches, which grow on the ridges and more elevated parts of the mainland of Nova Scotia and New Brunswick are found throughout

Prince Edward Island on the general level only a few feet above the sea. Finer specimens of *Abies balsamea*, *Picea alba*, *P. nigra*, *P. rubra* are found here rather than on the mainland, while the presence of *Thuja occidentalis* in isolated patches at the north end of the island is remarkable[1]).

The forests of Nova Scotia and New Brunswick are identic. A mild sea climate prevails on the side toward the Gulf of St. Lawrence and the hardwood trees are found on a lower level than along the Atlantic coast and Bay of Fundy. With exception of *Quercus macrocarpa*, *Juglans cinerea*, *Tilia americana* the following species are found in both territories:

Acer saccharum Marsh.
» rubrum L.
pennsylvanicum L.
Prunus serotina Ehrh.
» pennsylvanica Lf.
Fraxinus nigra Marsh. (= F. sambucifolia Lam.).
» americana L.
» pubescens Lam. (= F. pennsylvanica Marsh).
Ulmus americana L.
Betula populifolia Marsh.
» papyrifera Marsh.
lenta L.
nigra L.
Fagus americana Sweet.
Ostrya virginiana Koch (= O. virginica Willd.).
Populus tremuloides Michx.
» balsamifera L.
Salix nigra Marsh.
Pinus Banksiana Lamb. (= P. divaricata auth.).
» strobus L.
» resinosa Ait.
Picea alba Link.
» nigra Link.
» rubra Lam.
Abies balsamea Mill.
Tsuga canadensis Carr.
Larix americana Michx.
Thuja occidentalis L.

The coast species on the Atlantic and Bay of Fundy side, owing to the influx of cold winds, are chiefly the species of *Abies* and *Picea*, but a few hundred feet above the cold river valleys, we enter a forest composed of maple, beech, ash, birch with scattered spruce and pine (Betula-Fagus Facies), except in the west where tamarack, fir and spruce are the prevailing trees. (Larix-Abies-Picea-Facies). The elm, *Ulmus americana*, is found in the river valleys associated with birch and *Acer rubrum*; *Juglans cinerea*, *Tilia americana* and *Quercus macrocarpa* are found only in southern New Brunswick in some abundance, *Juglans* forming an open facies with the elm in abundance on the lower St. John.

*Deciduous Forest Formation.* This forest formation occupies the Maritime District and includes the following facies: Mixed Maple-Birch-Spruce-Fir Facies represents the culminating type of vegetation. This association occupies the areas of optimum drainage and hence of deep loose soils and moderate slopes provided by the glacial soils. The dominant members are *Acer saccharum* and *Betula papyrifera* with several secondary forms, being intermingled

1) MACOUN, JOHN: The Forests of Canada Proceedings and Transactions Royal Society of Canada XII (1894): 7—8. Sect. IV.

in mutual toleration with *Picea rubra*, *Abies balsamea* and an occasional white pine *Pinus strobus*. Beneath the canopy of these trees flourishes a subordinate layer of *Acer pennsylvanicum*, *Viburnum lantanoides* and on the ground various tall herbs: *Aralia nudicaulis*, *Streptopus roseus*, beneath which are *Oxalis acetosella* and *Clintonia borealis*. — In the beech facies, *Fagus americana* (= *F. ferruginea)* is the prevailing type. The paper birch *Betula papyrifera* forms an association where it dominates, as on the northern slope of Sagamook Mountain.

*Coniferous Forest Formation.* The hemlock, *Tsuga canadensis*, in western New Brunswick is perhaps next to the black spruce, the most abundant of the large trees of the district growing on the elevated grounds everywhere as far north as Grand Falls (Tsuga-Facies). The habitat of this tree is somewhat peculiarly restricted at least so far as New Brunswick is concerned. Rarely it is found on the southern side of the Baie des Chaleurs, north of Bathurst, or on the Restigouche, or to the north of Grand Falls, St. John, while in the interior of the province, south of a line extending from Bathurst to the mouth of the Tobique, it is one of the commonest and largest trees forming an almost pure forest with an undergrowth along the Saguenay River, as seen by the writer, of *Betula lutea*, *Acer pennsylvanicum*, *Taxus canadensis*, *Linnaea borealis*, *Monotropa hypopitys*, *Lycopodium annotinum*, *Circaea alpina*, *Vaccinium myrtilloides*, *V. ovalifolium*, *Calypso borealis* (= *C. Corallorhiza multiflora*), *Goodyera repens* etc.

The white pine association existed in the form of groves, formerly much more abundantly than now, with associated species (Pinus strobus-Facies), *Phegopteris* as a characteristic undergrowth with *Athyrium filix femina*, *Nephrodium dryopteris*, *Lycopodium dendroideum*, *L. annotinum*, *Clintonia borealis* in masses. — The forests on Miscou Island consist of the white spruce (*Picea alba*) *Abies balsamea* with aspen and paper birch, mountain ash and red dogwood. In especially low places there *Iris versicolor*, *Myrica gale* and *Hippuris vulgaris* appear, the white spruce is replaced by the white cedar *Thuja occidentalis*, f. e. in the forests of Miscou Island[1]). The red pine forms associations (Pinus resinosa-Facies) at the head of the Nepisiguit lakes; *Pinus Banksiana* exists in well marked associations (Pinus Banksiana-Facies) on the level bouldery plateaus along Portage Creek and on the neighboring part of the Nepisiguit.

In open glades, in these woods occur, Myrica (Comptonia) asplenifolia, Aster macrophyllus, Polygala paucifolium, Gaultheria procumbens, Epigaea repens, Pyrola secunda, Moneses uniflora.

The red spruce, *Picea rubra*, is the principal timber tree of New Brunswick. It occurs in groves with characteristic associates, while the black spruce association (Picea nigra-Facies) is notable for the fact that it occurs upon

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1) GANONG, W. J., in Botan. Gazette XLII: 81—106: The white cedar is also capable of existence upon higher grounds where conditions approach the Xerophytic, and so shows a marked dualism of habit.

flat bogs and in swampy places throughout New Brunswick and also is prevalent in central parts of the province covering loose boulders in markedly xerophytic situations, where it is associated with much hypnum and many heaths. Near mountain tops it forms a dwarf growth (Krummholz, or puckerbush: Dwarf Tree-Formation). — *Abies balsamea* forms the dominant and often almost the only tree in places in the interior of New Brunswick notably on Governor's Plateau where it occurs as an association (Abies balsamea-Facies). *Larix americana* enters into the tamarack swamp association (Larix-Facies) of general occurrence in the St. Lawrence-great Lake Region.

The forests of the Saguenay River which occupies a gorge with steep[1] and lofty cliffs are somewhat similar to those above described according to my observations. A brief sketch will suffice to give an idea of the flora of this river removed some distance inland from the Atlantic Ocean. The prevalence of coniferous trees is the marked feature of these forests. Larix americana, Abies balsamea, Thuja occidentalis, Picea nigra (= P. mariana) and P. alba (= P. canadensis) occupy boggy ground. The deciduous trees are Betula papyrifera, B. lutea, B. lenta, Ulmus americana, Populus tremuloides, Populus grandidentata, Fraxinus sambucifolia, Acer rubrum, A. saccharum with which are associated Sorbus americana and Sorbus sambucifolia which in rocky places are often reduced to shrubs. The alders Alnus viridis and A. incana are plentiful shrubs the latter forming dense thickets (Alder-Association) by water courses and swamps sharing the ground with Myrica gale, Corylus rostrata, Rhus typhina, Acer spicatum, Pinus Banksiana (= P. divaricata) and Pinus strobus are the only pines found on the Saguenay. Vaccinium pennsylvanicum, V. canadense abound on rocky ridges (Vaccinum-Association) and in pine land, while Vaccinium Vitis-idaea, Empetrum nigrum, Shepherdia (Lepargyraea) canadensis, Corydalis glauca, Campanula rotundifolia no less abundant are found on rocks along the St. Lawrence and the Saguenay rivers, which rocks are time stained by Buellia geographica, Parmelia centrifuga, P. stygia, P. Fahlunensis with Umbilicaria hyperborea etc. Ledum latifolium (= L. groenlandicum), Kalmia latifolia are not confined to bogs, but occur on sandy soil as well, with Epigaea repens, Chimaphila umbellata, Gaultheria procumbens, Pyrola elliptica, P. secunda, while Cassandra (Chamaedaphne) calyculata frequents the beds of peat.

The coniferous forest formation according to my observations made at Halifax, Nova Scotia consists of Pinus strobus. Picea nigra, Acer rubrum, Abies balsamea, while on the ground I saw Vaccinium vitis idaea, Cornus canadensis, Coptis trifolia, Pteris (Pteridium) aquilina, Clintonia borealis, Gaultheria procumbens, Maianthemum (Unifolium) canadense, Potentilla tridentata, Aralia nudicaulis, Vaccinium pennsylvanicum, Mitchella repens, Pyrola elliptica, Trientalis americana. Along Minas Basin as at Grand Pré the composition of the forest is Picea nigra, Pinus strobus, Larix americana together with Betula lutea, Acer rubrum, Betula populifolia, while according to my observations Nemopanthes fascicularis, Rosa lucida, Osmunda cinnamomea, Aralia hispida, Pteris (Pteridium) aquilina grow beneath the above mentioned trees.

*Mountains and Tableland.* An examination of the mountain flora[2]) (Sagamook mountain, ca. 700 m = 2,240 feet, one of the highest peaks in New Brunswick) shows three distinct belts of vegetation. The first of these consists of a dense growth of pines, firs and cedars, and extends about a third of the distance up the mountain side (Coniferous Forest-Formation). The second is composed principally of *Betula lutea* and *B. populifolia*, with a few cedars and alders reaching to a very considerable elevation Deciduous Forest: Betula-

1) Hill, E. J.: The Saguenay Region. Garden and Forest 1895: VIII: 182, 193, 213.

2) Bailey, L. W.: Notes on the Geology and Botany of New Brunswick. Canadian Naturalist second ser. I: 81—97.

Association. — The third belt is confined to the summit and a small portion of the slopes being covered with a low dwarf growth of shrubs *Ledum latifolium*, *Cassandra* (*Chamaedaphne*) *calyculata*, *Vaccinium uliginosum*. (Alpine Shrub-Formation.)

The great table-land and canyon walls of Mt. Albert in Gaspe: New Brunswick although exposing many square miles of alpine region, have a comparatively sparse flora: but the few species which abound there are of the greatest interest to the botanist, for, with but few exceptions, they are quite unknown upon any other mountains, or cliffs in eastern North America.

The plants which are strictly localized[1], in the rock crevices and on the talus slopes of Mt. Albert make up, so far as yet determined a flora of only 21 species (8.15 per cent of the 258 alpine and subalpine plants), but this flora includes the distinctive Adiantum pedatum var. aleuticum, Cryptogramme densa, Polystichum scopulinum. Deschampsia caespitosa var. alpina, Danthonia intermedia, Festuca altaica, Salix desertorum, S. chlorolepis, Lychnis (Viscaria) alpina, Arenaria ciliata var. humifusa, A. sajonensis, A. arctica, Statice sibirica, Solidago decumbens, Artemisia borealis, and var. Wormskioldii, Cirsium (Carduus) muticum var. monticolum. — The northern crests and slopes of Mt. Albert have in addition to common alpine plants the following noteworthy species: Carex lagopina, Luzula spicata var. tenella, Sagina Linnaei (Spergula saginoides L.), Ranunculus pygmaeus and R. Allenii.

## 2. The Hygro- and Halophytic Formations.

*River Bank Formation.* The following shrubs are to be found along the shores of the rivers:

Salix humilis, S. rostrata, S. discolor, Sambucus canadensis, Viburnum opulus, V. nudum, Sorbus americana, Corylus rostrata, Diervilla trifida, Prunus virginiana, Myrica gale, Nemopanthes fascicularis, Cephalanthus occidentalis, Ribes prostratum and associated with these is an herbaceous element also occurring on lake shores.

The banks of the Nepisiguit River are characterized by thickets of Viburnum opulus, V. pauciflorum, V. cassinoides, Nemopanthes, clumps of Osmunda regalis and ostrich fern, Onoclea struthiopteris[2]. The Sisson Branch of the Tobique River in New Brunswick narrows to a gorge through which the river runs in a series of rapids and cataracts. The gorge consists of perpendicular rocks on which grow Asplenium viride, Arnica mollis, Woodsia ilvensis, W. hyperborea (= W. alpina), W. glabella, Aspidium fragrans, and Erigeron hyssopifolius (= Aster graminifolius).

*Stream — (and Lake) — Bank Plant Formation.* This occupies the situations between the forest formation and those of the water, where the air conditions are mesophytic, but the roots conditions are hydrophytic. *Potentilla anserina*, *Ranunculus* (*Oxygraphis*) *Cymbalaria* grow on sandy ground at the mouth of streams. The alder, *Alnus incana*, is the dominant member of this very characteristic association often forming extensive alder swamps and also sometimes in drier places under xerophytic conditions. A distinct band of vegetation on the shores of the smaller northern lakes along the forest edge consists of *Myrica gale* and *Rhododendron Rhodora* (= *Rhodora canadensis*) and forms the Myrica-Rhodora association.

*Lake Formation.* The central part of Nova Scotia and other parts of the

1) FERNALD: The Soil Preferences of certain alpine and subalpine Plants, Rhodora IX: 149—193.

2) HAY, Transactions Royal Society Canada. Second series VIII sect. 4: 125—134.

maritime provinces of Canada are characterized by beautiful fresh water lakes, large and small. In one, I noted, large associations of *Pontederia cordata* with *Nymphaea (Castalia) odorata* occupying the spaces between the pickered weed. Other lakes were fringed by a tall species of *Scirpus* and *P. cordata*, while still others were occupied almost exclusively by *N. odorata* or *Nuphar advena*. *Nymphaea Kalmiana* and *Brasenia peltata* cover with the foregoing water plants the borders of shallow lakes in New Brunswick.

Four plants new to the flora of New Brunswick were found in the Nepisiguit lakes, viz., Ranunculus circinatus, Myriophyllum alterniflorum, Carex utriculata, var. minor and Potamogeton heterophyllus. Numerous Potamogetons and the floating heart, Limnanthemum lacunosum, grasses, carices and sedges fill the shallower parts of the lakes. Among them several rare forms occur most of which are new to New Brunswick: Glyceria borealis, Scirpus atrocinctus var. brachypodus, Carex canescens var. vulgaris, C. trisperma, C. sterilis var. excelsior, C. interior, C. stricta var. curtissima, C. rostrata var. ambigena, C. vesicaria var. jejuna[1]).

*Dry barrens.* The dry barrens, or Moor-Formation are characteristically treeless, but are surrounded by pine forests and on such areas grow lichens, mosses and ericaceous bushes, forming a heather. Here grow *Ledum latifolium*, *Vaccinium macrocarpon*, *Andromeda polifolia*, *Kalmia glauca*, *Betula pumila*, *Lonicera oblongifolia* with *Eriophorum vaginatum*, *Carex oligosperma* and Orchids, *Medeola*, *Linnaea*, *Mitella nuda*.

The great valley of the St. John River and its tributaries has a flora far more southerly in character than that of northern New Brunswick.

Onoclea struthiopteris, Aspidium aculeatum var. Braunii, Adiantum pedatum, Osmunda regalis, are some of the ferns of this valley, while Polygonatum biflorum, Trillium cernuum, Caulophyllum thalictroides, Thalictrum dioicum, Viola Selkirkii, Anemone virginiana, Vaccinium caespitosum, Cypripedium acaule, Asarum canadense, Sanicula marylandica, Sanguinaria canadensis, although not generally abundant, yet are not infrequently found along the upper St. John River. — Several plants are peculiar to this river: Oxytropis (Aragallus) campestris, Astragalus alpinus, Hedysarum boreale, Tanacetum huronense[2]). The rare plants of the New Brunswick phytogeographic area are *Dryopteris (Aspidium) fragrans*, *Woodsia glabella*, *Woodsia hyperborea*, *Oenothera (Onagra)* Oakesiana, Hieracium praealtum, Goodyera pubescens, Tanacetum huronense, Viola primulaefolia.

The calcareous slates of the mountain gorges are clothed with a luxuriant growth of mosses and ferns constituting a cliff plant formation with the following ferns forming associations: Polypodium vulgare, Asplenium viride, Cystopteris bulbifera, C. fragilis and Asplenium thelypteroides.

*Bog Formation.* Wherever, says GANONG, shallow impervious basins occur in which non-calcareous water accumulates, there sphagnum and other water mosses tend to grow and, preserved by the antiseptic properties of substances formed by themselves, do not decay but accumulate forming ultimately great bogs upon which woody plants may later grow[3]). There exists graded series of bogs from the typic flat bog on the one hand to the typic raised bog on the other. The bog formation consists of plants capable of existence in stag-

1) HAY, G. U.: Transactions Royal Society Canada, second series VIII. sect 4: 125—134.

2) HAY, G. U.: Botany of the upper St. John. Bulletin Natural History Society of New Brunswick II: 11—32; The Restigouche- with Notes especially on the Flora. Bulletin Natural History Society of New Brunswick. XIV, 1896: 12—35.

3) GANONG, W. F.: A preliminary Synopsis of the grouping of the Vegetation of the Province of New Brunswick. Bulletin of the Natural History Society of New Brunswick. 1902. No. XXI.

nant, but pure water. The bogs occupy the entire salt marsh country above the heads of the tide on the rivers, and also at places between rivers where drainage is obstructed. It includes three associations. By far the most extensive and characteristic bog association of the marshland is the floating-bog or Carex-Menyanthes-Association. The dominant plants form mats which float upon the surface of the standing water beneath which is the true marsh mud. As a rule the bog is firm enough to walk upon, though it trembles beneath the tread (quaking bog).

The dominant plants are *Carex filiformis, Eriophorum vaginatum, Carex stricta var. decora*, Carex magellanica, Eriophorum gracile and with these are associated Menyanthes trifoliata, Calla palustris. Upon the floating mat occur large areas of Equisetum limosum, Eleocharis palustris, Juncus canadensis, Sarracenia purpurea, Sparganium simplex, Myrica gale, Typha latifolia.

The basis of the common flat bog which occurs on the margins of lakes is a mixture of mosses of the genera *Hypnum*, *Dicranum*, with some *Sphagnum*; the latter playing, however, a subordinate part. The bulk consisting of mosses may be exceeded under certain conditions by other vegetation notably sedges, ericaceous shrubs, black spruce and larch. The ground and mosses in this Flat Bog Association are saturated with water, deep brown in color, of rather low temperature, carrying lime salts in solution and much vegetal matter in suspension. Peat is formed by the compaction of the vegetal remains[1]).

Raised bogs[2]) on the other hand which form a distinct association are composed of nearly pure *Sphagnum* with only traces of other mosses, mixed with a few culms of sedges and the slender roots of dwarf woody perennials. Throughout they are saturated with water, which is always cold and clear and free from salts of lime. In them there is no decay but the organic remains form later a spongy peat, never the compact peat of the flat bogs.

The flora of the raised bogs consist of sphagna which are of first importance. The following species of the genus *Sphagnum* enter into the raised bogs of New Brunswick.

Sphagnum cuspidatum. Edge of bogs.
» medium Limpr. Near edge of bogs.
» fuscum Klinggr. Makes up the bulk of the drier parts of the bog.
» imbricatum Hornsch. On dry parts with preceding.
» tenellum var rubellum Wils. f. dasyclada W. *Occupies the wetter places on the higher* part of the bogs.
» tenellum Klinggr. Near edge of bogs.
» recurvum P.B. var mucronatum Russ. On edge of bogs.
» recurvum var. parviflorum Sendt. On edge of bogs.
» Lindbergii Schpr. Extreme edge of bogs.
» Girgensohnii Russ. Extreme edge of bogs.

Several true mosses enter into the composition of the raised bog association: Polytrichum strictum, P. commune, Hypnum Schreberi, Dicranum spurium. Lichens are well represented on

1) Cf. Bastin, Edson S. and Davis, Charles A.: Peat Deposits of Maine Bulletin 376 U. S. Geological Survey 1909.

2) Ganong, W. F.: Upon raised peat Bogs in the Province of New Brunswick. Transactions Royal Society of Canada. Second ser. III Sect. IV: 131—163. 1897.

the surface of the bogs: Cladonia rangiferina, Cladonia uncialis, Cladonia Boryi, Cetraria islandica, while on the stunted trees of the bogs are Alectoria jubata, Parmelia saxatilis, Parmelia physodes, Usnea barbata, Cetraria lacunosa.

Around these bogs is found a dense spruce and larch forest encroaching on the bog where in the raised part they become reduced to a foot or less in height, viz., *Larix americana*, *Picea nigra*. The shrubs also grow on the margin, while on the bog they seldom exceed six or seven inches in height; *Ledum*, *Cassandra* (*Chamaedaphne*), *Kalmia glauca* and *angustifolia*, *Empetrum*, *Rubus chamaemorus*, *Vaccinium canadense*, *V. pennsylvanicum*, *V. caespitosum*, *Pyrus* (*Aronia*) *arbutifolia*. On the higher ground at the extreme edge of bogs are found *Rhododendron Rhodora*. Herbaceous plants are not numerous. The cotton-grasses *Eriophorum vaginatum* and *alpinum*, occur associated with *Scirpus caespitosus*, *Oxycoccus*, *Sarracenia*, *Drosera* etc.

*Wet Marsh Formation*. The wet marsh formation consists of plants capable of enduring much but not constant water at the roots, and otherwise able to meet the conditions of the meadow; hence composed of grasses and similar forms. The characteristic association of reclaimed marshes is the Spartina cynosuroides-Association.

It is composed of a single dominant member but several secondary forms, viz., Spartina cynosuroides with Cicuta maculata, Carex maritima, Calamagrostis canadensis, Scirpus atrovirens and of minor importance Triglochin maritimum, Thalictrum polygonum, Epilobium lineare, Lysimachia stricta, Iris versicolor, Campanula aparinoides and Scutellaria galericulata. The transition ara between the former association and the bog is occupied by the Carex-Aspidium-, or bogmarsh Association. It is found in places with constant hydrostatic water in the soil.

*Salt Marsh Formation*. The salt marshes of the Bay of Fundy have been studied by GANONG and the following account is an abridged statement of his observations of the distribution of plants there supplemented by those of the writer made in the summer of 1906. The wild salt marsh formation consists of several associations of species. The characteristic association of the immediate edge of the salt water extending typically as a strip just above and below ordinary high-tide mark and distinguished by its bright green color, and the stiff habit and close growth of its plants is the Spartina stricta-Association. The association comprises but a single vegetation form, as follows: *Spartina stricta* var. *glabra* (= var. *maritima*) the most characteristic and extreme salt-enduring plant of the marshes with perennial branching rootstocks running just beneath the surface and sheathed with leaf bases. The characteristic association of the newly formed and forming marsh occuring typically from the lowest high-tide marks to the highest marsh, hence overlapping the areas occupied by other associations, is the Salicornia-Suaeda-Association. In general its members are smaller, more stiffly upright, sparser and redder the greater the salt content of the soil, while in fresher soil the plants are more luxuriant spreading and greener. Two dominant plants[1]) are met with

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1) GANONG, W. F.: The Vegetation of the Bay of Fundy salt and diked Marshes. Botanical Gazette XXXVI: 161, 280, 429.

in this association *Salicornia herbacea* and *Suaeda* (*Dondia*) *linearis*, and as secondary form on higher, drier places *Spergularia* (*Buda*) *borealis* (= *Tissa canadensis*), *Atriplex patula* var. *hastata*.

The characteristic association of the higher salt marsh overflowed only by exceptionally high tides, and representing the highest development of salt-marsh vegetation is the Statice-Spartina juncea-Association. The plants are distributed on all the highest parts of the wild salt marsh and occupy the berme-bank built by the sea along the rivers. It is distinguished by its dull green color in various shades and the very dense, almost turf-like growth of its plants. It forms real salt meadow.

The Statice-Spartina-Association is composed of two dominant with several secondary and occasional members: Statice limonium var. carolinianum (= Limonium carolinianum), Plantago maritima, Spartina juncea, Puccinellia maritima, Festuca ovina, Juncus Gerardi, Triglochin maritimum, Hordeum jubatum, Glaux maritima. The dominant plants of the association are Spartina (fox-grass, or mezotte) and the Statice, with the Puccinellia and Plantago as important secondary members, and Festuca, Juncus, Triglochin, Hordeum as less important, while Glaux is subordinate. Occasional species are Spartina cynosuroides, Potentilla (Anserina) anserina.

*Salt Spring Plant Formation.* At certain salt springs near Sussex in the interior is found a colony of seashore plants: such as *Salicornia*, *Spergularia marina* and *borealis*, *Ranunculus Cymbalaria*, *Atriplex patula* var. *hastata*, *Distichlis spicata*. The explanation of the distribution is historic. During the latest post-glacial subsidence this region dipped beneath the sea to extent of 200 feet. The marine coast plants thus followed the sea into the interior. The subsequent elevation of the land, with the return of fresh water everywhere exterminated the halophytic plants except where salt abounded namely, at these springs[1]).

*Strand Formation.* The beaches of the St. Lawrence River at Cacouna for example show a strand formation of several associations constituted by the grouping of *Cakile americana*, *Lathyrus maritimus*, *Mertensia maritima*, *Plantago maritima*, *Arenaria* (*Ammodenia*) *peploides* and other plants. In the tide-swept mud along the Saguenay River grow *Spergularia* (*Tissa*) *marina* and *Plantago maritima*; on wet rocks or sands *Lathyrus*, *Glaux*, *Ligusticum scoticum*, *Solidago sempervirens*, *Atriplex patula* var. *hastatum*[2]).

The most characteristic plant of the beach of Miscou Island in the Gulf of St. Lawrence is Salsola kali with *Cakile* americana (= *C.* edentula) next in abundance, while *Mertensia maritima* and Lathyrus maritimus occupy third place. Here and there are found Atriplex patula var. hastata (= A. hastata), Ammophila arenaria. Inside the open beach, according to GANONG, begins the sand plain of parallel dunes covered with Ammophila arenaria and this grass offers shelter to Carex silicea, Taraxacum officinale, Rumex acetosella, Botrychium ternatum var. intermedium, Anaphalis margaritacea and in sheltered places Rosa lucida, Viola adunca, Smilacina (Vagnera) stellata and Vicia cracca. The hollows are occupied by Fragaria virginiana and Festuca

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1) GANONG, W. F.: On halophytic Colonies in the Interior of New Brunswick. Bulletin Natural History Society of New Brunswick. No. XVI, 1898.

2) ROBINSON, C. B.: Science new ser. XXVI: 665 also GANONG, W. F.: The nascent Flora of the Miscou Beach Plain. Botanical Gazette XLII: 81.

rubra, while the sheltered slopes afford a place where Juniperus sabina var. procumbens (= J. sabina) grows together with Myrica carolinensis, Hudsonia tomentosa, Vaccinium pennsylvanicum. The sandy beach gradually merges into the coniferous forest behind. The woody vanguard consists of mats of Juniperus combined with Vaccinium pennsylvanicum. Myrica carolinensis, Hudsonia tomentosa. Here also are found Empetrum nigrum, Potentilla tridentata, and less frequently Cladonia rangiferina, Gentiana amarella var. acuta (= G. acuta). On the other hand, the beach merges into sandy swales, bordered by spruce. Here the turf consists of Festuca ovina var. rubra (= F. rubra), Poa pratensis, Agrostis alba, Juncus Vaseyi, Carex Oederi, together with Euphrasia americana, Antennaria neodioica, Sagina procumbens, Plantago major, Potentilla norvegica and Trifolium repens.

*Marine Algal Formation.* The marine flora of the Maritime District of the St. Lawrence-Great Lake Region is essentially arctic in character as may be inferred from their boreal position and their exposure to cold currents from the north polar region. In New Brunswick the action of the tides on the southern shores renders it impossible for any marine algae but the stronger forms to maintain themselves, except in sheltered coves, while on the other hand the low sandy shores extending into the Gulf of St. Lawrence do not furnish a favorable habitat for algae. Fuci and Laminariae are distributed in abundance along the whole coast. The fuci growing between tide marks are most abundant on the south coast; two species are common. *Fucus vesiculosus* and *Ascophyllum nodosum*; but *F. evanescens*, *F. furcatus* are uncommon (Fucus Shelf). The shelf of Laminariae extends from low-water mark to several fathoms in depth. These plants occur in greatest profusion on the coast of the Gulf of St. Lawrence. Three species occur, the most generally diffused being *Laminaria longicruris* with *L. saccharina* and *L. digitata*.

Scattered in endless profusion are Delesseria sinuosa, D. alta var. angustissima, Chorda filum, Agarum Turneri, Alaria esculenta. Rhodymenia palmata, Porphyra laciniata, P. vulgaris are found to a more limited extent especially on the coast of the Gulf of St. Lawrence. Polysiphonia fibrillosa found on the north side of the Island of Miscou, has hitherto been detected only at one place north of Cape Cod. Odonthalia dentata found at various points on the Gulf of St. Lawrence and on the southern shores of Nova Scotia has not been collected on the New England coast[1].

## 3. High Mountains of New England. Formations on Mt. Katahdin.

*Coniferous Forest Formation.* Mount Katahdin, Maine, a long elevated ridge several miles in length and 5,215 feet (1590 m) above sea level is situated in the midst of a spruce forest consisting of *Picea nigra* (= *P. mariana*), *Pinus strobus* (in detached groves; Pinus strobus-Facies), *Betula papyrifera*, *Betula lutea*, *Abies balsamea*, *Sorbus americana*, *Thuja occidentalis* (sparingly), *Acer rubrum* with an undergrowth of *Acer spicatum*, *Amelanchier oligocarpa*, *Nemopanthes fascicularis*, *Ribes prostratum*, *Viburnum pauciflorum* and *Taxus canadensis* in considerable abundance. The forest floor is covered in most places especially where boulders occur with a mat of mosses consisting chiefly of three forms:

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1) HAY, U.: Marine Algae of New Brunswick. Proceedings and Transactions of the Royal Society of Canada. 1887 V sect. IV: 167—174; Bulletin Natural History Society of New Brunswick VI: 62.

*Hypnum Schreberi*, *H. crista-castrensis* and *Hylocomium splendens*, with the liverworts *Ptilidium capillare*, *Bazzania* (*Mastigobryum*) *trilobata*.

Out of this mossy covering grow according to my observations [1] Cornus canadensis, Coptis trifolia, Chiogenes hispidula, Clintonia borealis, Habenaria fimbriata, Trientalis americana, Lycopodium lucidulum, Oxalis acetosella, Listera cordata, Dalibarda repens, Linnaea borealis, Phegopteris polypodioides (= P. phegopteris), Pyrola rotundifolia var. uliginosa: The drier better drained soil of the more open forest is characterized by Epigaea repens, Monotropa uniflora, M. hypopitys, Anaphalis margaritacea, Campanula aparinoides, Pyrola secunda, Vaccinium canadense, while in the marshy places in the woods grow Veratrum viride, Drosera rotundifolia, Osmunda regalis.

This coniferous forest formation (Picea-Abies-Facies) covers the Great Basin, South Basin, the Northwest Basin, most of the outer slopes and ridges and extends far out into the lowlands about the mountain. Ascending the basins the trees gradually become smaller until at the base of the last long precipitous ascent we come to the tree line which has its delimitation in large trees. Above this exists the Krummholz, or pucker-bush (Dwarf Tree Formation) which reaches far up toward the summit.

The dwarf timber consists of ancient black spruce trees Picea nigra (= P. mariana) associated with Pyrus (Sorbus) americana, Alnus viridis (= A. alnobetula), Spiraea salicifolia, Empetrum nigrum, Ledum latifolium (= L. groenlandicum), while on the steeper slopes grows Betula papyrifera var. cordifolia. Juniperus communis and Eriophorum alpinum are on the ledges of the back wall of the North Basin with the southeastern exposure (Rock Cliff Formation) associated with an adventurous colony of lowland plants. [2]: Lycopodium clavatum, Osmunda claytoniana (= O. interrupta), Pteris (Pteridium) aquilina, Carex leptalea, C. flava, Danthonia spicata, Smilacina (Vagnera) racemosa, Andromeda polifolia, Aster umbellatus, Aster radula, Aster acuminatus, Prunus pennsylvanica, P. virginiana, Diervilla trifida, Potentilla (Dasiphora) fruticosa, Viola Selkirkii which invade the territory of such plants as Diapensia lapponica, Bryanthus taxifolius, Arnica Chamissonis and Epilobium Hornemanni at about 4,000 to 4,500 feet (1220—1472 m) altitude.

*Alpine formation.* It is widely distributed covering more than one half the upper part of the mountain. On the crest, summits and table-land it reaches perhaps its highest and most characteristic development extending down upon the saddle spurs and higher slopes [3]. With the accumulation of the soil through the activity and decay of the plants in the above-mentioned associations the grasses and sedges first appear and form a mat by their interlacing roots.

Deschampsia-Carex-Association: Hierochloe (Savastana) alpina, Agrostis rubra, Deschampsia flexuosa, Carex vulgaris var. hyperborea (= C. Bigelovii), C. canescens var. alpicola (= C. brunnescens) and Juncus trifida are common pioneer elements of the alpine tundra, associated with such mosses as Polytrichum juniperinum, P. commune, P. ohioense and Mielichhoferia nitida var. elongata. — Empetrum-Vaccinium Association: This association may be said to form the culmination of the alpine formation. It consists of Empetrum nigrum, Vaccinium vitis idaea, V. pennsylvanicum var. angustifolium, V. uliginosum, Diapensia lapponica, Ledum latifolium

1) Harshberger, J. W.: A botanical Ascent of Mount Katahdin, Maine. The Plant World V: 26. Feb. 1902.

2) Williams, Emile F.: A Comparison of the Floras of Mt. Washington and Mt. Katahdin. Rhodora III: 164. June 1901.

3) Harvey, Le Roy H.: A Study of the physiographic Ecology of Mount Katahdin, Maine. University of Maine Studies. No. 5. December 1903.

(= L. groenlandicum), Kalmia angustifolia, K. glauca, Arctostaphylos alpina, Rhododendron lapponicum while of less general distribution occur Cassiope hypnoides, Loiseleuria (Chamaecistus) procumbens, Bryanthus taxifolius, Arnica chamissonis, Comandra livida and Gnaphalium supinum.

## List of Alpine Plants of Mt. Katahdin.

Lycopodium selago L.
» annotinum L. var. pungens Spring.
Abies balsamea Mill.
Juniperus communis L.
Hierochloe (Savastana) alpina R. & S.
Phleum alpinum L.
Cinna pendula Trin. (= C. latifolia Trev.).
Deschampsia atropurpurea Scheele.
Trisetum subspicatum Beauv.
Danthonia spicata Beauv.
Scirpus caespitosus L.
Eriophorum alpinum L.
Carex atrata L. var. ovata Boott. (= C. atriformis Britton).
» arctata Boott. var. Faxoni Bailey.
» flava L.
» communis Bailey (= C. pedicellata Dewey).
» leptalea Wahl.
Salix argyrocarpa Anders.
» phylicifolia L.
» uva-ursi Pursh.
» herbacea L.
Betula papyrifera Marsh. var. cordifolia Regel.
» glandulosa Michx.
Arenaria groenlandica Spreng.
Stellaria borealis Bigelow.
Cardamine bellidifolia L.
Drosera rotundifolia L.
Saxifraga stellaris L. var. comosa Willd. (= S. comosa Poir.).
Ribes lacustre Poir.
» prostratum L'Her.
Prunus pennsylvanica L. f.
Fragaria virginiana Duchesne.
Potentilla (Sibbaldiopsis) tridentata Ait.
Sorbus (Pyrus) americana Marsh.
Amelanchier oligocarpa Roem.
Empetrum nigrum L.
Viola palustris L.
» canina L. var. (= V. arenaria DC.).
Epilobium anagallidifolium Lam.
Cornus canadensis L.
Ledum latifolium Ait. (L. groenlandicum Oeder).
Rhododendron lapponicum Wahl.
Bryanthus taxifolius Gray (= Phyllodoce coerulea L.).
Cassiope hypnoides Don.
Arctostaphylos (Mairania) alpina Spreng.
Vaccinium caespitosum Michx.
» pennsylvanicum Lam. var. angustifolium Gray.
» vitis-idaea L.
Diapensia lapponica L.
Castilleja pallida Kunth var. septentrionalis Gray (= C. acuminata Pursh).
Euphrasia Oakesii Wettst.
Lonicera caerulea L.
Solidago Virga aurea L. var. alpina (= S. alpestris Wald. & Kit.)
Aster radula Ait.
» (Doellingeria) umbellatus Mill.
» acuminatus Michx.
Arnica chamissonis Less.
Prenanthes (Nabalus) nana Torr.
» ( » ) Bootii Gray[1].

1) FERNALD, M. L.: Vascular Plants of Mt. Katahdin Rhodora III: 166. June 1901.

*Alpine Meadow Formation.* Situated at the base of the dripping west wall of the North Basin and so presenting a warm south-eastern exposure associations of meadow species occur which culminate in a shrubby covering to the meadows. The pioneer association which appears in the crevices of the dripping walls consists of *Scirpus caespitosus*, *Campanula rotundifolia*, *Solidago alpestris*, *Potentilla tridentata*, *Arenaria groenlandica*, *Carex scirpoidea*, *Luzula spicata* and *Juncus articulatus* (= Luzula-Juncus-Association). — With the increase of humus and water holding capacity of the soil the next stage appears. The association now consists of *Aster* (*acuminatus*, *radula*, *umbellatus*), *Castilleja*, *Prenanthes nana* (= *P. trifoliata*), *Anaphalis margaritacea* with such grasses as *Calamagrostis canadensis*, *C. Langsdorfii*, *Bromus ciliatus*, *Glyceria nervata*, *Agropyrum violaceum* (= *biflorum*), *Agrostis rubra*, and in association with these grasses *Solidago macrophylla*, *Viola blanda*, *Arnica Chamissonis*, *Heracleum lanatum* and *Habenaria dilatata*. — The last stage of all culminates with the appearance, according to HARVEY, of *Diervilla trifida*, *Spiraea salicifolia* var. *latifolia* associated with such secondary species as *Ribes prostratum*, *Lonicera caerulea*, *Rubus strigosus* and *R. canadensis*.

*Pond Formation* The ponds of glacial origin at the foot of the mountain and the sphagnum bogs derived from them merit passing attention. The shores of the ponds are usually rock strewn and slope off to some depth. *Alnus viridis* and *Betula papyrifera* var. *cordifolia* form a fringing circumarea of vegetation with *Cassandra*, *Spiraea salicifolia*, *Kalmia angustifolia*, *Ledum*, *Myrica gale* in the sphagnum circumarea inside the alder belt. The shallow water of the pond shore is characterized by the presence of *Isoetes heterospora*, and *echinospora* var. *Braunii*, *Potamogeton confervoides*, *Lobelia Dortmanna*, *Nymphaea odorata* var. *minor*, *Nuphar Kalmianum*.

The Sphagnum-Association occurs in morainic depressions with a life history dating back to the glacial period. The Sphagnum advances from the edge of ponds and finally covers them, when a quaking bog is formed. Scheuchzeria palustris appears followed by Drosera rotundifolia, D. longifolia, Sarracenia purpurea, Vaccinium oxycoccus, Smilacina trifolia, and when the conditions become drier by Eriophorum gracile, Carex trisperma, Carex pauciflora, succeeded in turn by the Cassandra-Association (see ante). The entire absence of bog orchids, is noteworthy. Empetrum, Vaccinium uliginosum, V. vitis-idaea also figure in the succession of species. Finally Picea nigra (= P. mariana), Larix americana (= L. laricina), Thuja occidentalis encroach on the bog and convert it gradually into forest.

### 4. Formations on Mt. Washington, New Hampshire.

The highest point in the Presidential range in the White Mountains is Mount Washington, 6,300 feet (1932 m) in elevation. The base of the mountain is surrounded by a forest which represents a southern extension of that typic of central and northern Maine and New Brunswick. The forest which surrounds Mount Katahdin in Maine is essentially the same as that which surrounds Mount Washington, only that the hemlock *Tsuga canadensis* is more abundant about the flanks of the latter mountain.

*Coniferous Forest Formation.* Originally the entire northern division of the state of New Hampshire was covered with a dense forest of conifers. It was primarily a spruce country[1]) and the spruce *Picea rubra* (= *P. rubens* Sarg.) here attained fine dimensions. White pine, *Pinus strobus*, too, covered large areas and was mixed with spruce over much of this country. *Abies balsamea* occurred in mixture on the upper slopes and in the lower moister localities. There was originally very little pure hardwood in the forest, and if present it was confined to the lower slopes with the spruce in mixture. Associated with the trees mentioned above were *Acer saccharum*, *Fagus americana* (= *F. ferruginea*) and *Thuja occidentalis*. South of the northern forest mentioned, the flora belongs to the New England Area, but it may be stated here that some of the southern species like the white oak, *Quercus alba* and the red oak *Q. ruba*, here reached their northern limits and mingled with those more characteristic of the north.

In the White Mountain region *Abies balsamea* and *Picea nigra* (= *P. mariana*) grow together in about equal numbers (Abies-Picea-Facies). North of the mountains these trees with *Thuja occidentalis*, are the prominent evergreens mingled with *Picea alba* about Connecticut Lake. In the southern part of New Hampshire, they are mostly confined to the highlands between the Merrimac and Connecticut rivers, the black spruce *Picea nigra* being there the most abundant tree. *Tsuga canadensis* ranges from the base of the White Mountains southward along the highlands. (Tsuga-Facies). It has its northern limit in the vicinity of Umbagog Lake reaching an elevation of 1,200 feet above the sea. *Larix americana* is found in swamps. — To sum up, the original forest formations of the White Mountain country were two viz., the coniferous forest formation including the spruce flat facies, the spruce slope facies and the deciduous forest formation.

Spruce Flat Facies. Spruce flats occurred in the moister, lower situations, on the level or rolling land around lakes and streams and in the valleys. Picea nigra (= P. mariana) and Abies balsamea were the chief species, and on the wetter soils Picea nigra (= P. mariana), Thuja occidentalis and Larix americana were also common. There was often considerable yellow birch, Betula lutea and red maple, Acer rubrum. Pinus strobus and Tsuga canadensis were also found in great abundance in this formation.

Spruce Slope Facies. This type of forest occurred on the steeper slopes where the soil is shallow. The principal species were Picea nigra (= P. mariana) and Abies balsamea in varying proportions, and yellow birch, Betula lutea, changing often to paper birch, B. papyrifera on the upper slopes. The stand was usually dense and where the forest was undisturbed the ground was covered with moss. This formation covered the greatest area of any of the forest types in northern New Hampshire[2]), finally characterized as a scrubby growth near the mountain summits.

*Deciduous Forest Formation.* On the lower slopes and deeper better soils hardwoods form a large part of the growth. Here *Betula lutea, Acer saccharum* and *Fagus americana* are the characteristic trees, with considerable spruce

1) CHITTENDEN, ALFRED K.: Forest Conditions of northern New Hampshire. U. S. Bureau of Forestry, Bulletin 55. 1905.

2) CHITTENDEN, loc. cit. page 25.

*Picea nigra* in mixture. This type of forest rarely extends above an altitude of 2,400 feet (732 m). The ground cover consists of *Viburnum lantanoides* (= *V. alnifolium*), *Acer pennsylvanicum* and *Sorbus americana*.

*Alpine Formations*. The timber line on Mount Washington averages 4,000 feet (1220 m). The dwarf timber (Krummholz, pucker bush, Dwarf Tree Formation) is clearly demarcated but not so extensive as on Mount Katahdin[1]. *Picea nigra* gradually degenerates until it becomes flat-topped and closely matted together while in the ravines above tree limit are dense thickets of *Alnus viridis*. The summit of Mount Washington is bare in the extreme and characterized by angular boulders of granite covered with lichens: *Buellia geographica*, Umbilicariae, Cetrariae, Cladoniae. Enormous ravines seam the sides of the mountain designated as Great Gulf, Tuckermans Ravine, Huntingdon Ravine. These ravines support a variety of rare and local mountain and alpine species.

Alpine Canyon Formation. In Tuckermans Ravine above the snow arch the writer collected Salix phylicifolia, Gnaphalium supinum, Phleum alpinum, Castilleja pallida, Veronica alpina. Arnica chamissonis, Habenaria dilatata, Viola palustris, Streptopus amplexifolius, and A. J. GROUT reports in addition Alnus viridis (= A. alnobetula, A. crispa), Oxyria digyna, Salix argyrocarpa, Sibbaldia procumbens, Loiseleuria procumbens, Epilobium alpinum and Geum radiatum (= G. Peckii), while Heracleum lanatum, Veratrum viride, Houstonia coerulea, Cornus canadensis, Linnaea borealis have ascended from the valleys to mix with the alpine species. The presence of the rare Viburnum pauciflorum, Baeomyces placaphyllus in this ravine is noteworthy, while the fungus Doassansia epilobii is found nowhere else in the world. Oxyria digyna, Cassiope hypnoides, Bryanthus taxifolius (= Phyllodoce caerulea), Castilleja pallida, Geum radiatum, Diapensia lapponica, Veronica alpina, Stellaria borealis, Epilobium anagallidifolium, Luzula arcuata, L. spicata, Potentilla tridentata, Juncus trifidus, Salix herbacea, Salix phylicifolia, Lycopodium selago, Coptis trifolia were noticed by me at the head of the great Gulf where Oxyria digyna, *Saxifraga rivularis with Cardamine bellidifolia form an association in the dripping rivulets* (Oxyria-Association). The other plants form an association of varying character according to the predominance of any one or two species occurring on the shelves of the steep declivities of this ravine, (Cassiope-Bryanthus-Diapensia Association). The mosses of the great Gulf rim are Dicranum fulvellum growing in the crevices of moist cliffs; Conostomum boreale also occurs, while on wet banks of rivulets are Rhacomitrium fasciculare, Hylocomium squarrosum, Gymnocybe turgida, Hypnum fluitans, H. dilatatum, H. stramineum.

The summit plants divide themselves into two groups those found amid the boulders and on the steeper slopes and those found on the plateau known as the Alpine Garden.

The *Alpine Garden according to my observations* is a level table-land slightly inclined downward some distance below the summit. The plants are characterized by their short stature (nanism) scattered over the surface with pebbly, stony, sandy, or clayey soil between the plants and an abundance of lichens and mosses. The flowering plants mostly assume the cushion form and have a multicipital perennial root, or rhizome (Alpine Fell-field Formation)[2]. On the protected upper edge of the garden which is practically alpine in its meteorologic and physiographic features occur stunted groups of Picea nigra (= P. mariana) which are closely matted together

1) Cf. SHAW, C. H.: Causes of Timber-line on high Mountains. The Plant World XII: 169.

2) WARMING, EUG. and VAHL, M.: Oecology of Plants; an Introduction to the Study of Plant Communities 1909: 256—261.

(Picea-Association). Where the conditions are especially favorable they may be 1—2 feet high. Ledum latifolium (= L. groenlandicum) is abundant in almost pure growth (Ledum-Association). Potentilla (Sibbaldiopsis) tridentata forms pure association (Potentilla-Association) as also Diapensia lapponica (Diapensia-Association). Geum radiatum, Arenaria groenlandica, Empetrum nigrum, Solidago virgaurea var. alpina, Vaccinium vitis-idaea, Houstonia coerulea, Lycopodium selago are abundant, while Veratrum viride, Castilleja pallida var. septentrionalis (= C. pallida), Epilobium anagallidifolium, Stellaria borealis form an association in wet places (Castilleja-Association). Silene acaulis, Arctostaphylos (Mairania) alpina. Rhinanthus cristagalli, Polygonum viviparum have all been found on the eastern border of the Garden.

Bog Formation. The sphagnum bogs on the summits are filled with Empetrum nigrum, *Vaccinium (Oxycoccus) oxycoccus, Carex magellanica, C. pauciflora, Prenanthes (Nabalus) Bootii,* Diapensia lapponica, Vaccinium caespitosum are found in exposed situations, Polygonum viviparum in the dry cold clefts; Viburnum pauciflorum, Salix phylicifolia in moist alpine ravines; Salix uva-ursi, S. balsamifera, Betula papyrifera var. minor among the alpine rocks and Comandra livida in evergreen shaded bogs.

The constituent flora of the summit proper of Mt. Washington is characterized by the great, abundance of Arenaria groenlandica with such other plants as Rhododendron lapponicum, Diapensia lapponica, Prenanthes (Nabalus) Bootii, P. (N.) nana, Carex rigida, Poa laxa, Loiseleuria (Chamaecistus) procumbens, Silene acaulis, Geum radiatum var. Peckii, Potentilla (Sibbaldiopsis) tridentata, Solidago virgaurea var. alpina (= S. alpestris), Vaccinium vitis-idaea, Phleum alpinum, Lycopodium selago, while Sibbaldia procumbens the rarest of White Mountain plants and lost to sight for many years has recently been (1904) rediscovered on Mount Washington.

Flowering-times of some alpine species:

June 30th. Vaccinium uliginosum and caespitosum, Cassiope, Bryanthus, Kalmia glauca, Rhododendron lapponicum, Loiseleuria, Diapensia, Oxyria digyna, the three Salices, Betula glandulosa, *Empetrum and Viburnum pauciflorum. Silene acaulis, Cardamine bellidifolia, Juncus* trifidus, Carex rigida var. Bigelowii, Carex scirpoidea, Luzula spicata.

July 4th. Vaccinium Vitis idaea, Ledum latifolium, Rubus chamaemorus, Viola palustris, Paronychia argyrocoma, Geum radiatum var. Peckii, Potentilla tridentata, Castilleja pallida var. septentrionalis, Hierochloë borealis and alpina.

July 10th. Arenaria groenlandica, Epilobium alpinum, Arnica mollis, Prenanthes (Nabalus) nana, Veronica alpina, Polygonum viviparum, Phleum alpinum, Agrostis canina, Poa laxa, Habenaria obtusata and dilatata.

August 1st. Solidago virgaurea var. alpina, Prenanthes (Nabalus) Bootii, Alectorolophus Cristagalli.

The following is the list of plants[1]) found in New Hampshire only on alpine summits. Those found also in Europe are marked by an asterisk.

*Polygonum viviparum L.
*Oxyria digyna Hill.
*Empetrum nigrum L.
*Betula glandulosa Michx.
Salix uva-ursi Pursh.
 » argyrocarpa Anders.
* » herbacea L.
*Cardamine bellidifolia L.
*Viola palustris L.
*Silene acaulis L.
Arenaria groenlandica Spreng.
*Dryas integrifolia Vahl.
Geum radiatum Michx. var. Peckii Pursh.
*Sibbaldia procumbens L.
*Potentilla frigida. Man. ed. 6 (= P. Robbinsiana Oakes.).
*Saxifraga rivularis L.

1) This list is made up from my list of plants; also in Among the Clouds XXIV: 3 July 28 1900; HITCHCOCK, C. H.: The Geology of New Hampshire I: 571. 1874.

*Epilobium alpinum L. var. majus.
*Solidago virgaurea L. var. alpina Bigel. (= S. alpestris Wald. & Kit.).
*Gnaphalium supinum L.
Arnica chamissonis Less.
Prenanthes (Nabalus) nana Torr.
» ( » ) Bootii Gray.
*Vaccinium uliginosum L.
» caespitosum L.
*Arctostaphylos (Mairania) alpina [Spreng.
Cassiope hypnoides Don.
*Bryanthus taxifolius A. Gray (= Phyllodoce coerulea L.).
*Rhododendron lapponicum Wahl.
*Loiseleuria (Chamaecistus) procumbens Desv.
*Diapensia lapponica L.
*Veronica alpina L.
*Castilleja pallida Kunth var. septentrionalis Gray.

*Luzula spicata DC.
*Juncus trifidus L.
*Scirpus caespitosus L.
*Carex scirpoidea Michx.
* » capitata L.
* » rigida Gooden. var. Bigelovii Torr.
* » atrata L.
* » capillaris L.
*Phleum alpinum L.
Agrostis canina L. var. rubra L.
Calamagrostis Pickeringii A.Gr. (= C. breviseta A. Gray).
» Langsdorfii Trin.
*Poa laxa Haenke.
Hierochloë (Savastana) borealis R. & S.
* » » alpina R. & S.

*Lycopodium selago L.
* » annotinum L. var. pungens Spring.

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## 5. Formations on Mt. Mansfield.

Mt. Mansfield, 4,364 feet (1330 m) is on the western branch of the Green Mountains in Vermont. It is a long range of four peaks separated from Sterling Mountain on the northeast by Smugglers Notch, a narrow pass three miles long, enclosed by tremendous cliffs. There are but two plants found in Willoughby Notch Vermont which are not duplicated on Mt. Mansfield. These are *Sisymbrium humile* and *Aster polyphyllus* (= *A. Faxoni* [1]).

An analysis of the flora of Smugglers Notch made by J. W. HARSHBERGER in August 1906 shows the following disposition of the species. The forest in the gorge and on its slopes up to a considerable elevation consists of *Betula lenta*, *B. lutea*, *Fagus americana*, *Acer saccharum*, *A. rubrum*, *Tsuga canadensis* (scattered), while as secondary trees are found *Acer pennsylvanicum*, *Viburnum lantanoides* and young trees of the dominant ones. The herbaceous plants scattered between the schistic slabs are f. e. *Actaea alba* and *rubra*, *Tiarella cordifolia*, *Asarum canadense*, *Viola rotundifolia*, *Monotropa uniflora*, *Mitchella*, *Medeola*, *Coptis trifolia*, *Cornus canadensis*, *Oxalis*, *Impatiens*, *Trillium erythrocarpum*, *Clintonia borealis*, *Adiantum pedatum*. (Deciduous Forest Formation; Acer-Fagus-Betula-Facies). — Ascending the gorge slopes until the lower

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1) RIDLER, CHARLES, E.: The Flora of Willoughby Notch. Appalachia IV: 64—68. 1884—1886; DEANE, WALTER: A Trip to Willoughby Lake, Vt. Botanical Gazette XI: 112—116. 1886.

cliffs are reached (1000 feet above the stream) the coniferous forest appears. This also clothes the highest summits of Mt. Mansfield and the Green Mountains. The Coniferous Forest Formation owes its character to *Abies balsamea*, *Picea nigra*, while *Betula lenta*, *B. lutea*, *B. papyrifera*, *Sorbus americana* are intermixed, but never dominant. On the rocky cliffs and outcrops these trees assume a more, or less, dwarfed aspect. *Prunus pennsylvanica* also occurs as an element of this forest. Bogs are interspersed and in these bogs sphagnum forms the substratum out of which *Ledum groenlandicum* and *Chiogenes hispidula* grow. (Bog Formation). On the highest levels of Mt. Mansfield there is found in a depression between the exposed rocks of the summit an area, two or three acres in extent, occupied by an alpine bog. The substratum of this bog is a brown peat two feet thick, the surface being covered with sphagnum out of which grow principally, sometimes mixed, sometimes in pure association, the following plants: *Vaccinium vitis-idaea*, *V. uliginosum*, *V. pennsylvanicum* var. *angustifolium*, *V. oxycoccus*, *Cassandra calyculata*, *Ledum latifolium*, *Empetrum nigrum*, while in wetter bogs on the mountain top is found *Veratrum viride*. Occasionally dwarf creeping balsam, *Abies balsamea* encroaches on the alpine bogs. *Ledum* is perhaps the most abundant woody perennial of the top of Mt. Mansfield and *Vaccinium ulginosum* stands second.

Alpine Cliff Formation. The cliffs in Smugglers Notch are precipitous and show a varied flora. Among the cliff plants noted by me, and described by Mrs. STRAW were Saxifraga aizoon, S. oppositifolia, S. aizoides. On the wet cliffs Pinguicula vulgaris grows together with Woodsia glabella. The drier cliffs are characterized by Woodsia ilvensis, Draba incana, Woodsia hyperborea, Asplenium viride, Pellaea gracilis, Aspidium fragrans, Arenaria verna var. hirta, and Aspidium aculeatum var. Braunii.

The rocks of the highest summits are carpeted with Arenaria groenlandica, Vaccinium uliginosum, V. vitis-idaea, V. pennsylvanicum var. angustifolium, Carex Bigelovii, C. debilis var. Rudgei, also Arenaria verna var. hirta, Gentiana amarella var. acuta (= G. acuta), Luzula spicata, Festuca ovina var. brevfolia, Carex atrata var. ovata.[1].

## b) New England Area.

The flora of this area is characterized by the absence of *Picea alba*, *Pinus Banksiana* and by the presence of *Pinus strobus* and other trees found in the New Brunswick area, but its chief characterization depends on the presence of such trees as *Quercus alba*, *Q. prinoides*, *Q. coccinea*, *Juniperus virginiana* and *Castanea dentata* (= *C. americana* in the southern part), which here reached their northern limit, so that it may be looked on as a transition territory between the Canadian white-pine forests and the broad-leaved forests further south. It comprises littoral and mountain territories.

1) For details consult EGGLESTON, W. W.: The Flora of Mt. Mansfield: Botanical Gazette XX: 72—75; BIGELOW, CARRIE E.: A Trip to Mt. Mansfield in June. Plant World II: 105—107; FARLOW, W. G.: Notes of Cryptogams from the higher mountains of New England. Proceedings Boston Society Natural History XXV: 387; PRINGLE, C. G.: Notes on alpine and subalpine Plants in Vermont. American Naturalist X: 741; STRAW, CARRIE, E.: The ferns of Smugglers and Nebraska Notches. Plant World VI: 180—181.

## 1. Plant distribution on Sea Islands.

The outer islands lying off the Maine coast have a flora of a triple character[1]. The wooded portions have the trees of the mainland, (Coniferous Forest Formation), *Abies balsamea*, *Picea alba*, *P. rubra*, *Betula papyrifera*, *Populus tremuloides*, *P. balsamifera*, while on Peaks Island J. W. HARSHBERGER noted small groves of *Quercus rubra*. Under their shelter grow the characteristic smaller plants of the northern flora: *Acer spicatum*, *Rhodora*, *Coptis*, *Cornus canadensis*, *Linnaea*, *Arisaema triphylla*, *Habenaria bracteata*, *H. lacera*, *Liparis Loeselii* etc. Thickets of *Alnus maritima* also occur according to HARSHBERGER's observations. The cleared portions, however, harbor a great number of species introduced or adventive.

Smaller islands hardly more than an acre may show such plants as Cakile americana, Lathyrus maritimus, Ligusticum scoticum, Solidago sempervirens, Mertensia maritima, Suaeda linearis, Ammophila arenaria, plants of the sea coast together with Ribes hirtellum, Geranium Robertianum, Potentilla anserina, Rubus strigosus, Oenothera biennis, Archangelica Gmelini, Ambrosia artemisiaefolia, Achillea millefolium, Convolvulus sepium, Scutellaria galericulata, Plantago decipiens, Triglochin maritimum and Iris versicolor. On the shore line of larger islands such as Great Duck Island, twelve miles south of Mt. Desert Island, and on Cushing's Island occur Salsola, Salicornia, Suaeda, Cakile, Statice limonium var. carolinianum, Euphorbia polygonifolia, Spartina patens, Ammophila, plants also common to the sandy sea beaches of New Jersey and farther south, but in addition to these are plants peculiar to the northern sea shore: Ranunculus cymbalaria, Ligusticum scoticum, Mertensia maritima, Plantago maritima.

One of the marked characteristics of the flora of Mt. Desert country is its strongly northern and arctic character. With its coast enveloped in cold fogs and washed by waters chilled by the arctic current, such arctic plants like *Montia fontana* and *Stellaria humifusa* find a congenial home. With the single exception of *Lycopodium Selago* the mountain plants descend to sea level. The flora shows points of great similarity to those of New Brunswick and the White Mountain region. After the glacial period Mt. Desert Island, as now, was disconnected from the mainland. It is, therefore, natural that there should exist in abundance on the mainland many plants that are not found at all on the island, or only there rarely. Again the flora of the Cranberry islands is different from that of Mt. Desert. Under almost precisely similar conditions, we find *Corema Conradii* on the larger island, but not on the Cranberry isles; we find *Montia fontana*, *Stellaria humifusa* and *Rubus chamaemorus* on the Cranberry isles, but not on Mt. Desert; we find *Symplocarpus foetidus* and *Hippuris vulgaris* on the Cranberry isles and also on Mt. Desert Island[2].

Hudsonia tomentosa with Lechea minor, L. maritima, Helianthemum majus occur on high dry ground, while the sand barren plants are Viola

1) REDFIELD, JOHN H.: Insular Floras. Bulletin Torrey Botanical Club XIII: 245; COOK, MABEL P.: Plants seen on the Island Monhegan, Maine. Rhodora 1901 III: 187.

2) RAND, EDWARD L. and REDFIELD, JOHN H.: Flora of Mount Desert Island, Maine 1894: 21—22.

sagittata var. ovata, Polygala polygama, Trifolium arvense, Tephrosia (Cracca) virginiana, Prunus maritima, Chrysopsis falcata, Diplopappus (Doellingeria) lineariifolius, Arctostaphylos uva-ursi; Kalmia angustifolia, Asclepias obtusifolia, Salix tristis, Cypripedium acaule, Pinus rigida. The bulk of the underbrush consists of Rhus copallina, Pyrus (Aronia) arbutifolia, Amelanchier canadensis, Viburnum dentatum, Myrica carolinensis, Myrica gale, Rhododendron (Azalea) viscosum, Andromeda ligustrina, Gaylussacia frondosa, G. resinosa, Vaccinium corymbosum, V. vacillans, V. pennsylvanicum, while on the ground are Epigaea repens, Gaultheria procumbens, Trientalis americana and Potentilla argentea[1]). Some of these plants form a pine barren element stronger than in Nantucket and must be considered as northeastward migrating plants. (Sand Barren Formation).

At present, the island of Nantucket is practically treeless, but there is abundant historic evidence that this island when first settled was generally forest clad and that the trees of oak and pine were sufficiently large to afford ship-timber. Nevertheless the flora of Nantucket is extremely rich and varied. A peculiar feature is the presence of *Opuntia vulgaris* and *O. Rafinesquii* in the region north of Coatue Sound about Great Head. *Quercus ilicifolia* associated with *Epigaea repens* is still abundant in the scrub form on the commons and with several other plants represents the northeastern extension of the pine barrens.

Corema Conradii, Arctostaphylos uva-ursi, Hudsonia ericoides, H. tomentosa occur on the plains of Nantucket, but Calluna vulgaris and Erica cinerea, E. tetralix are striking elements in the flora.

In some swamps a few trees are found: *Quercus alba* and *rubra*, *Hicoria alba*, *Fagus*, *Nyssa*, *Ilex opaca*.

The flora of Block Island may be divided into that of the hills, the peat bogs and pond holes, the salt marshes, the sand dunes and the salt water, the latter being exclusively algal, except for *Zostera*. W. W. BAILEY and J. F. COLLINS list 294 species of the flowering plants and ferns found by them on the island. The island is practically treeless and hence devoid of such vegetation as is depend upon growth under a forest cover. But there is abundant evidence that a tree flora formerly existed, consisting of pine, oak, beech, hickory. Block Island lacks the plain flora of southern affinity found on Long Island, Martha's Vineyard and Nantucket. This is explained by reference to the past geologic history of the island. At the close of the ice age, there was a continuous strip of land, in fact the seaward extension of the great terminal moraine, separable into two portions an elevated northern border and a southern plain representing what remained of the old Tertiary coastal plain. Since the glacial period, Block Island has lost all of its plain region and the accompanying flora, and is now merely an isolated portion of the terminal

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1) HOLLICK, ARTHUR: **Observations on the Geology and Botany of Martha's Vineyard. Transactions New York Academy of Sciences 1893—94 XIII: 17—21.**

moraine with small areas of sand-beach and dunes, affording a place for such species as can exist under such conditions. The geologic indications are that Block Island was the first strip of land to be isolated and converted into an island. The flora of the plain region, coming largely from the south and possibly always having existed close to the ice front would be the first to advance and occupy the ground, while that of the moraine, being of a more northern type could not become established, says HOLLICK[1]) until the conditions due to glaciation northward had become modified, so that it could exist there and become established on such morainal deposits, as those which constitute the northern portion of Block Island.

## 2. Sea coast Formations.

The flora of the sea coasts of the New England Area may be divided into that found on the rocky shores and that confined to the sandy beaches and dune areas. *The rocky cliffs and iron-bound coast line are perhaps the most* extensive with small sandy beaches between formed by tidal action. These latter may be neglected in our discussion, because their vegetation is more characteristically developed on the peninsula of Cape Cod which may be taken as representative of the halophytic flora.

*Rock Cliff Formation.* The rocks of the coast according to the observations of J. W. HARSHBERGER on Mount Desert Island, Maine, and Conanicut Island, Rhode Island are bare of vegetation, where the storm-waves dash, but beyond the reach of the tide in Maine *Empetrum nigrum* forms dense matted cushions associated with *Juniperus sabina* var. *procumbens*, *Solidago sempervirens* and on sandy shores *Cakile americana*, *Salsola Kali*, *Mertensia maritima.*

*Strand Formation.* The typic sand beach and sand dune formation in eastern Massachusetts consists of such plants, as

| | |
|---|---|
| Cakile americana Nutt. (= C. edentula Bigel.). | Artemisia Stelleriana Bess. |
| Prunus maritima Wang. | » caudata Michx. |
| Euphorbia polygonifolia L. | Salsola Kali L. |
| Chenopodium rubrum L. | Xanthium canadense var. echinatum Gray. |
| Atriplex arenaria Nutt. | Ammophila arenaria L. (= A. arundinacea Host.). |
| Glaux maritima L. | Polygonella articulata Meisn. |
| Arenaria (Ammodenia) peploides L. | Solidago sempervirens L. |
| Triodia (Triplasis) purpurea Hack. | Spergularia (Buda) marina L. |
| Statice limonium carolinianum Gray (= Limonium carolinianum Walt.). | Salicornia ambigua Michx. |

On Cape Cod the beach plants form a strip just above the action of the tides. Cakile americana, Lathyrus maritimus, Xanthium canadense var. echinatum, Euphorbia polygonifolia may

1) HOLLICK, ARTHUR: Notes on Block Island. Annals New York Academy Sciences 1898 XI: 55—88; BAILEY, W. W. and COLLINS, J. F.: List of Plants found on Block Island, R. I. in July and August. Bulletin Torrey Botanical Club XX. 1893: 231—239.

be mentioned as typic species. The beach plants in southwestern Connecticut are Spergularia marina, Diodia teres, Polygonella, Triodia, Aristida tuberculosa, Salicornia herbacea, S. ambigua. The dunes and dune faces support Ammophila, Salsola Kali, Solidago sempervirens, Hudsonia tomentosa, Artemisia caudata with Myrica carolinensis, Rosa lucida and Prunus maritima removed some distance back from the sea beach.

The shore plants of Nantucket island are Arenaria peploides, Lathyrus maritimus, Hudsonia, Ligusticum, Solidago sempervirens, Baccharis halimifolia, Xanthium, Mertensia, Salicornia ambigua, Suaeda linearis var. ramosa, Salsola Kali, Amaranthus pumilus, Polygonum articulatum, P. maritimum, Ammophila, with the shrubs Prunus maritima and Myrica carolinensis.

*Salt Marsh Formation.* The species which enter into the phyto-geographic associations of the Salt Marsh Formation which occupies the mud flats covered by the sea in extremely high tides are tabulated below[1]).

Juncus Gerardi Loisel.
Spartina juncea Willd.
» stricta glabra Gray.
Scirpus maritimus L.
» pungens Vahl.
Distichlis spicata L. (= D. maritima Raf.).
Triglochin maritima L.
Iris prismatica Pursh.
Typha angustifolia L.
Carex maritima O. F. Muell.
Salicornia mucronata Bigel. (= S. Bigelovii Torr.).
Suaeda (Dondia) linearis Moq.
Atriplex patula var. hastata Gray (= A. hastata L.).
Spergularia (Tissa) marina L.
Statice limonium var. carolinianum Gray (= Limonium carolinianum Walt.).
Gerardia maritima Raf.
Puccinellia maritima Parl.
Iva frutescens Man. ed. 6 (= I. oraria Bartlett).
Pluchea camphorata DC.
Solidago sempervirens L.
Aster subulatus Michx.
» tenuifolius L.
Potentilla anserina L.
Samolus valerandi var. americanus Gray (= S. floribundus H.B.K.).
Hibiscus moscheutos L.
Sabbatia stellaris Pursh.

The salt marshes at York, Maine and as far south as Cape Cod are covered by a vegetation which consists primarily, according to PENHALLOW[2]) of *Spartina stricta* var. *alterniflora* which grows along the open channels, *Spartina patens* back of the taller species and usually in higher ground mingled with sea lavender *Statice Limonium* var. *carolinianum*, *Salicornia* and *Solidago sempervirens.*

The sand hook which exists at the extreme point of Cape Cod is bordered by an extensive salt marsh. The typic marginal species is Salicornia ambigua and the characteristic grasses of the marsh are Spartina polystachya, S. patens associated with Juncus Greenii, J. canadensis, Scirpus pungens (= S. americanus), while the marsh partially converted by sand into a fresh-water marsh is covered by extensive patches of Vaccinium macrocarpon, surrounded by Cyperus Grayi and Carex silicea. When such areas become fresh water swamps, there appear species of Eleocharis, Fimbristylis autumnalis, Xyris caroliniana, Eriocaulon septangulare etc[3]).

1) BLANKINSHIP, J. W.: The Plant-Formations of eastern Massachusetts. Rhodora V: 124—137 May 1903.

2) Transactions Royal Society of Canada third series I sect. 4: 25.

3) HOLLICK, ARTHUR: Cape Cod and Chappaquidick Island. Mass. Bulletin New York Botanical Garden II: 381—407. April 25, 1902.

### 3. Marine Algal- and Plankton Formation.

The marine plants of the northeastern coast of North America naturally arrange themselves in several shelves[1]), the Ulva shelf, the Fucus shelf, the Laminaria-Chondrus shelf and the Deep Sea shelf.

*Ulva Shelf.* On this shelf *Ulva latissima* is found in great abundance. Wherever pools of water are left by the tide, this plant occurs and I have found it plentifully on Conanicut Island growing in the pools formed in the exposed slate rock of the coast at that point.

Four species of Enteromorpha are found on this shelf Enteromorpha intestinalis, E. compressa, E. clathrata, E. Hopkirkii. Along with these and firmly adhering to the rocks clumps of Cladophora rupestris, C. uncialis, C. flexuosa are found, and also gelatinous masses of Hormotrichum Youngianum. *Here is also a dwarf species of Fucus. It grows in the corners and crevices of* water pools and may be a form of F. vesiculosus.

*Fucus Shelf.* The first and uppermost plant is *Fucus* (*Ascophyllum*) *nodosus* ranging as far south, as New York Bay. It covers a belt of shore from one to three yards in breadth and is frequently covered by *Ceramium rubrum.* It grows below it and retains more water among its fronds than the previous more leathery plant. It is parasitized by *Elachistea fucicola* and *Ectocarpus siliquosus* and completely covers the rocks upon which it grows. *Fucus furcatus* occupies the chief place in what might be termed the third sub-shelf. It is found at the ordinary low water mark and is scarcely ever altogether out of the water. Under its folds *Chondrus norwegicus?* occurs adherent to the rocks with *Gigartina mamillosa.*

The pools at this depth are the homes of Chondrus crispus, Halasaccion ramentaceum, Cystoclonium purpurascens together with Hypnea musciformis, Chordia flagelliformis, Rhodymenia palmata, Porphyra laciniata, Chaetomorpha melagonium, with Delesseria sinuosa in the deeper and more shady pools.

*Laminaria-Chondrus Shelf.* The marine algae of this shelf are *Agarum Turneri*, *Alaria esculenta*, *Laminaria digitata*, *saccharina*, *fascia*, *phyllitis*, *dermatodea*, while at greater depths is found *Chondrus crispus*, which grows in great abundance south to Long Island.

*Deep Sea Shelf.* The finer American marine algae occur in deep water. *Laminaria longicruris* eight to twelve feet long occurs here as far south as Cape Cod. The prevailing deep sea algae are *Rhodymela subfusca*, *Delessaria sinuosa*, *alata*, *denticulata*, *Euthora cristata*, *Phyllophora membranifolia*, (not common), *Ptilota serrata* and *elegans*, *Punctaria tenuissima*, *Polysiphonia fibrillosa.*

The following is a list of the marine algae found on the shores of Penikese Island[2]).

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1) KEMP, REV. ALEX. F.: On the shore Zones and Limits of marine Plants on the northeastern coast of the United States. Canadian Naturalist and Geologist 1862: VII: 20.

2) JORDAN, PROF. D. S.: The Flora of Penikese Island. American Naturalist 1874 VIII 193—197.

### Chlorophyceae.

Bryopsis plumosa Lam.
Enteromorpha intestinalis Link.
» Hopkirkii M'Calla.
» compressa Grev.
» clathrata Grev.
Ulva latissima L.
Cladophora areta Dillw.
» lanosa Roth.
» glaucescens Griff.
» flexuosa Griff.
Cladophora albida Huds.
» gracilis Griff.
» fracta Fl. Dan.
Chaetomorpha melagonium Web. & Mohr.
» aerea Dillw.
» Olneyi Harv.
Hormotrichum Younganum Dillw.
Calothrix confervicola Ag.
» scopulorum Ag.

### Rhodophyceae.

Rhodomela subfusca Ag.
Polysiphonia formosa Harv.
» subtilissima Mont.
» Harveyi Bailey.
» elongata Grev.
» violacea Grev.
» variegata Ag.
» nigrescens Grev.
» affinis Harv.
» fastigiata Grev.
Dasya elegans Ag.
Corallina officinalis L.
Grinellia americana Harv.
Delessaria sinuosa Lam.
Gelidium corneum Lam.
Rhodymenia palmata Grev.
Phyllophora Brodiaei Ag.
Griffithsia corallina Ag.
Callithamnion Baileyi Harv.
» Barreri Ag.
» byssoideum Arn.
» corymbosum Ag.
» scirospermum Griff.
» plumula Lyngb.
» americanum Harv.
» Turneri Ag.
» Daviesii Ag.
» luxurians Ag. [1]).
Champia parvula Harv.
Ahnfeltia plicata Fries.
Cystoclonium purpurascens Kg.
Chondrus crispus L.
Ceramium rubrum Ag.
» diaphanum Roth.
» fastigiatum Harv.
» arachnoideum Ag.

### Phaeophyceae.

Sargassum vulgare Ag.
» Montagnei Bailey.
Fucus (Ascophyllum) nodosus L.
» vesiculosus L.
Desmarestia viridis Lam.
Laminaria saccharina Lam.
» digitata Lam.
» fascia Ag.
» longicruris Pylaie.
Dictyosiphon foeniculaceus Grev.
Punctaria tenuissima Grev.
Asperococcus echinatus Grev.
Chordaria flagelliformis Ag.
» divaricata Ag.
Leathesia tuberiformis Gray.
Elachistea fucicola Fries.
Sphacelaria cirrhosa Ag.
Ectocarpus littoralis Lyngb.
» siliculosus Lyngb.

*Pelagic Benthos Formation.* The plankton vegetation off the New England coast has not been studied, but some investigation has been made of the bacterial flora [1]). Quantitatively the marine mud in the vicinity of Woods Hole contains much less germ life than that of the Mediterranean in the vicinity of Naples. The Naples cultures made from mud taken at the depth of 150 feet

1) RUSSELL, H. L.: The bacterial Flora of the Atlantic Ocean in the Vicinity of Woods Hole, Mass. Botanical Gazette 1893 XVIII: 383, 411, 439.

or less, yielded usually from 200—300,000 germs per c. c., while those made at Woods Hole in only exceptional instances exceeded 50,000 germs, while the average content was about 15—20,000 per unit of volume. *Bacillus limicola*, a common chromogenic species, inhabits exclusively the ground layers of the sea bottom in America. Three other forms *Bacillus pelagicus*, *maritimus* and *litoralis* comprise the major portion of the bacterial flora of Woods Hole and are found both in the water and the underlying ground layers. These where distributed through the water at all depths and *Bacillus pelagicus* and *maritimus* were abundant in samples of mud taken at a distance of 100 miles from land and in 450 feet of water.

### 4. Bog-, Swamp- and Pond-Formations.

*Bog Formation.* This formation is characterized by the abundance of *Sphagnum* species which form a dense growth over the surface and maintain more equable conditions of moisture and temperature. They may be called islands of northern plants with many ericaceous species. The plants of this formation in eastern Massachusetts are:

Calla palustris L.
Clintonia borealis Raf.
Habenaria lacera R.Br.
Pogonia ophioglossoides Ker.
Calopogon pulchellus R.Br. (= Limodorum tuberosum L.).
Arethusa bulbosa L.
Cladium mariscoides Torr.
Rhynchospora alba Vahl.
Eriophorum gracile Koch.
» vaginatum Am. auth. (= E. callithrix Cham.).
Smilacina trifolia Desf.
Drosera rotundifolia L.
» intermedia Hayne.
Sarracenia purpurea L.
Utricularia cornuta Michx.
Menyanthes trifoliata L.
Epilobium lineare Muhl (= E. densum Raf.).
Geum rivale L.
Vaccinium macrocarpon Ait.
» oxycoccus L.
Cassandra (Chamaedaphne) calyculata Moench.
Andromeda polifolia L.
Kalmia glauca Ait.
Ledum latifolium Ait.
Rhododendron Rhodora Don.
Chiogenes hispidula T. & G. (= serpyllifolia Salisb.).

The cold sphagnum bogs of Vermont have an interesting flora, but in the tabulated list below the preponderance of species of Carex (13) and Eriophorum (4) is probably due to the greater care taken in the collection and identification of these typic bogs plants.

Calopogon pulchellus R.Br.
Calypso borealis Salisb. (= C. bulbosa L.).
Arethusa bulbosa L.
Habenaria dilatata Gray.
Listera cordata R.Br.
Microstylis (Achroanthes) monophyllos Lindl.
Orchis rotundifolia Pursh.
Poa pratensis L. var. angustifolia Smith.
Carex tenuiflora Wahl.
» teretiuscula Gooden.

Carex trisperma Dewey.
Dulichium spathaceum Pers. (= D. arundinaceum L.).
Eleocharis pauciflorus Link.
Eriophorum alpinum L.
» gracile Koch.
» vaginatum L.
Scirpus atrocinctus Fernald.
Carex chordorrhiza L. f.
Carex exilis Dewey.
» folliculata L.
» fusca Man. ed. 6.
» livida Willd.
» magellanica Man. ed. 6.
» oligosperma Michx.
» pauciflora Lightf.
» saltuensis Bailey.
» tenella Schkuhr.

The same Ericaceae are noted from Massachusetts bogs, without Rh. Rhodora, the same Sarracenia, Geum, and the following trees, shrubs and perennials:

Picea nigra Link.
Salix candida Fluegge.
» myrtilloides Man. ed. 6 (= S. pedicillaris Pursh).
Viburnum cassinoides L.
Myrica gale L.
Potentilla palustris Scop.
Lonicera caerulea L.
» oblongifolia Goldie.
Rhamnus alnifolia L'Her.
Aster junceus Ait.
Senecio Robbinsii Oakes.
Solidago uliginosa Nutt.
Pyrola secunda L. var. pumila Gray.
» uliginosa Torr.
Amelanchier canadensis T. & G. var. oblongifolia Roem.
Solidago neglecta T. & G.
Valeriana sylvatica Banks (= V. septentrionalis Rydb.).

In many places the forests to be considered later encroache on the bogs converting them into boggy woodlands. In a study of certain salt marshes on the New England coast PENHALLOW finds that sphagnum bogs have been invaded by Menyanthes trifoliata, Cassandra calyculata, Vaccinium macrocarpon, Cyperaceae and other plants until in the lapse of time the surface of the bog was in a condition to support the white pine, Pinus strobus. Then through the destruction of the sea barrier, salt water suddenly covered the converted bog which was changed into a salt marsh. The history of such salt marshes are shown by excavation and Penhallow from a study of the marsh layers believes that it has taken approximately 420 years for these changes to take place while the previous sphagnum growth was indefinite.

*Swamp Formation.* This formation is coincident with open swamps and marshes. The water is shallow, the soil is covered with water, but in summer the water dries up leaving the soil of such swamps partially dry. The plants of this formation are entirely different from those that form the bog associations. They appeared in the region at a later period than the bog plants, as we have shown in a former chapter. The following plants are usually amphibious, or emersed:

Pontederia cordata L.
Alisma Plantago-aquatica L.
Sagittaria variabilis Engelm. (= S. latifolia Willd.).
» heterophylla Pursh (= S. rigida Pursh).
Acorus Calamus L.
Peltandra virginica L. (= P. undulata Raf.).
Sparganium eurycarpum Engelm.
» simplex Huds.
Typha latifolia L.

Iris versicolor L.
Carex stricta Lam.
Zizania aquatica L.
Glyceria fluitans R.Br.
Ludwigia (Isnardia) palustris L.
Proserpinaca palustris L.
Cicuta maculata L.
» bulbifera L.
Sium cicutaefolium Gmel.
Lathyrus palustris L.
Decodon (Nesaea) verticillatus Ell.
Veronica scutellata L.
Bidens chrysanthemoides Michx. (= B. laevis L.).
Caltha palustris L.
Cardamine pennsylvanica Muhl.
Rumex britannica L.
Equisetum limosum L.

*Mud Pond Formation.* This formation exists in ponds and slow-flowing streams with mucky, clay bottom. The plants of the table have their upper leaves floating, rarely submerged.

Chara fragilis Desv.
Nitella flexilis Ag.
Marsilia quadrifolia L.
Podostemon ceratophyllum Michx.
Naias flexilis R. & S.
Potamogeton crispus L.
» natans L.
Elodea (Philotria) canadensis Michx.
Vallisneria spiralis L.
Ranunculus multifidus Pursh (= R. delphinifolius Torr.).
Myriophyllum spicatum L.
Callitriche heterophylla Pursh.
Nuphar (Nymphaea) advena Ait.
Nymphaea (Castalia) odorata Ait.

This formation also includes the free floating vegetation of fresh water ponds, streams and ditches including

Utricularia vulgaris L.
» purpurea Walt.
» inflata Walt.
Riccia fluitans L.
Lemna minor L.
» trisulca L.
Spirodela polyrhiza Schleid.
Riccia natans L.

*Sand Pond Formation.* BLANKINSHIP thinks this formation distinct enough from the preceding to merit separate treatment. The bottoms of the ponds where the vegetation of this formation occur, are sandy with little humus. The plants named below are usually submersed with their upper leaves floating:

Myriophyllum tenellum Bigel.
» ambiguum Nutt. (= M. humile Raf.).
Naias indica var. gracillima A.Br. (= N. gracillima A.Br.).
Hottonia inflata Ell.
Eriocaulon septangulare With.
Proserpinaca pectinata Lam.
Limnanthemum lacunosum Griseb.
Potamogeton spirillus Tuckerm.
Sagittaria teres Wats.
Orontium aquaticum L.
Lobelia Dortmanna L.
Brasenia peltata Pursh (= B. purpurea Michx.).
Nuphar Kalmianum Sims.
Nymphaea odorata Ait.
Lycopodium inundatum L. var. Bigelovii Tuckerm.

The margin of such sand ponds is fringed by a number of characteristic herbs that will grow in wet, open sandy places. Several of the plants mentioned

above also grow in more or less dry soil assuming under varying conditions an amphibious habit.

When mats of floating vegetation become anchored other plants appear, viz., species of *Utricularia*, *Carex*, *Xyris*, *Drosera*, while *Decodon* (*Nesaea*) *verticillatus* plays a leading part in binding the mats together. Following *Decodon* are *Clethra alnifolia*, *Rhododendron viscosum*, *Vaccinium corymbosum*, *Ilex*, *Myrica carolinensis* and *Gale*, *Andromeda ligustrina*, *Cassandra*, and finally these shrubs are overshadowed by trees of *Chamaecyparis sphaeroidea* (= *C. thyoides*) and the series enters the culminating stage as a cedar swamp[1]).

### 5. Forest- and Hill Barren-Formation.

For convenience in treatment the forests of the New England Area will be treated under two heads, viz., the forests of southern Maine, central and southern New Hampshire, eastern Massachusetts and those of southern New England. This represents the transition area from the broad-leaved forest of the south to the coniferous forest of the north. The white pine, *Pinus strobus*, mixes here with *Quercus alba* and *Castanea dentata* (= *C. americana*) although it is prominent enough still as an element to bind this territory as a phytogeographic area to that of the New Brunswick Area, where the *Pinus strobus* is even more abundant.

*Deciduous Forest Formation.* The trees found in moist soil and deep humus often spoken of collectively as rich woods are *Pinus strobus*, *Platanus occidentalis*, *Acer rubrum*, *Tilia americana*, *Ulmus americana*. *Acer saccharum*, *Quercus coccinea* and *Fraxinus americana*.

The shrubby undergrowth is formed by Amelanchier canadensis var. oblongifolia, Alnus incana, Alnus serrulata, Ampelopsis (Parthenocissus) quinquefolia, Rhus radicans and the following herbs on the ground in the shade of the trees: Arisaema triphyllum, Maianthemum (Unifolium) canadense, Circaea lutetiana, Aralia nudicaulis, Boehmeria cylindrica, Viola pubescens, Viola blanda, Sanguinaria canadensis, Trillium cernuum, Uvularia (Oakesia) sessilifolia, Erythronium americanum, Impatiens fulva (= I. biflora), Pilea (Adicea) pumila.

The forests of the hilly uplands occur on argillaceous soils with slate or granite base often glacial drift, and such situations are often denominated "dry hillsides", "rocky slopes", etc. The trees in such places are *Quercus alba*, which ascends to the Connecticut River valley as far as the foot hills of the White Mountains and in another direction sweeps northeastward into Maine a little north of Lake Winnepesaukee, while the chestnut *Castanea dentata* follows the same line of distribution a little south of the white oak, reaching the southern margin of the aforementioned lake. Also the botanist finds *Quercus tinctoria* (= *Q. velutina*), *Q. rubra*, *Carya alba* (= *Hicoria ovata*), *C. porcina* (= *H. glabra*), *Prunus serotina*, *Populus tremuloides*, *Sassafras*

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1) SHAW, CHARLES H.: The Development of Vegetation in the morainal Depressions at Woods Hole. Botanical Gazette XXXIII: 437. June 1902.

*officinale*, *Ostrya virginiana*, *Fagus americana* and *Tsuga canadensis* associated with the shrubs *Rhus*, *Corylus*, *Rubus*, *Vaccinium vacillans* and a assortment of herbaceous plants of wide range. Near the coast, as on Cape Cod, where the soil is sandy and usually level the forest is open and the pitch pine *Pinus rigida* is the principal tree.

This open forest merges into the Sand Barren Formation where grow associated together *Hudsonia tomentosa*, *H. ericoides*, *Lechea minor* var. *maritima*, *Hypericum nudicaule*, *Cyperus filiculmis* and *Grayi*, *Corema Conradii*, *Smilax rotundifolia*, *Arctostaphylos uva-ursi*, etc.

The hardwoods predominate largely except in eastern Massachusetts and northeastern Connecticut and Rhode Island where *Pinus strobus* occurs in solid groves on gravel ridges, and on the sandy borders of streams and ponds. *Juniperus virginiana* comes up in old fields especially in southern Connecticut, *Tsuga canadensis* grows in all sections. The oaks are the most common trees except in the Berkshires where *Picea nigra*, *Abies balsamea*, *Acer saccharum*, *Betula lutea* and *papyrifera*, *Fagus* occur. In eastern Massachusetts *Quercus alba*, *Q. coccinea*, *Quercus rubra* occupy the best situations and on loose sands and gravels accompany *Pinus strobus*. *Castanea dentata* is one of the commonest trees and in Connecticut it forms 60 per cent of the forest on rolling land and on the very best soils is mixed with *Liriodendron tulipifera*, *Fraxinus americana* and *Tilia americana*[1]). Little of the virgin forest is left in Connecticut, but in North Colebrook is a small remnant comprising a mixture of *Pinus Strobus*, *Tsuga canadensis*, *Betula lutea*, *Castanea dentata* (some places 60 per cent of stand), *Quercus alba*, *Q. rubra*, *Acer saccharum*, *A. rubrum*, *Prunus serotina* and *Fraxinus americana*, while of secondary importance occur *Betula populifolia*, *B. lenta*, *Quercus prinus* (on rocky ridges), *Q. coccinea*, *Platanus occidentalis* (in river bottoms), *Liriodendron tulipifera* (in moist soil), *Tilia americana*, *Juglans cinerea*, *Sassafras*, *Ulmus americana*, *Carpinus caroliniana*, *Ostrya virginiana*, *Cornus florida* and *Corylus americana*[2]). In swamps in southern New England, *Acer rubrum* is the characteristic and often the only tree. It is accompanied on the wettest ground by *Ulmus americana*, *Quercus palustris* and *bicolor*, *Fraxinus sambucifolia*.

Such a swamp forest occurs on the north shore of Long Island at the head of St. John's Pond near Cold Spring Harbor, according to Transeau. The forest is composed of Quercus alba, Nyssa sylvatica, Liriodendron tulipifera, Fraxinus americana as the dominant trees with an under growth of Hamamelis virginiana, Viburnum molle, Azalea (Rhododendron) viscosa, Clethra alnifolia, Alnus incana, Smilax rotundifolia, Rhus radicans, Lindera benzoin (= Benzoin benzoin), Andromeda (Xolisma) ligustrina, and such herbs as Osmunda cinnamomea, Symplocarpus (Spathyema) foetidus, Viola cucullata, Trillium cernuum, Arisaema triphyllum, Carex crinita, C. Asa-Grayi (= C. Grayi), Veratrum viride and Dryopteris noveboracensis.

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1) Graves, H. S. and Fisher, R. L.: The Woodlot: Handbook for Owners of Woodlands in southern New England Bull. 42 Bureau of Forestry U. S. Department Agriculture 1903.

2) Hawes, Austin F. and Hawley, Ralph C.: Forest Survey of Litchfield and New Haven Counties, Connecticut. Conn. Agric. Exper. Stat. Bull. 162.

*Hill Top Barren Formation.* Where high points of slate or granite are exposed by denudation, a characteristic formation occurs. Sometimes this formation (usually local) is found on rocky cliffs. The trees which grow in the ledges are in dry soil under xerophytic condition, consequently the number of arborescent species is small. *Quercus prinoides*, *Q. ilicifolia*, *Juniperus virginiana*, *J. communis* var. *alpina*, *Prunus pennsylvanica*, *P. virginiana* and *Pinus rigida* comprise the list of trees occuring in such places associated with *Vaccinium pennsylvanicum*, *Rhus typhina* etc.

*Sand Plains Formation.* Certain sand plains near North Haven, Connecticut are covered with a xerophytic vegetation composed of *Andropogon scoparius* (in tufts), *Cyperus filiculmis*, *Sporobolus*, *Syntherisma*, *Trichostema*, *Polygonella*, *Hypericum nudicaule*, *Asclepias Cornuti* (*syriaca*), *Baptisia*, *Helianthemum*, *Artemisia caudata*. — *Juniperus virginiana*, *J. communis*, *Prunus serotina*, *Quercus tinctoria* var. are the dominant trees and grow in scattered groups while certain areas are covered with *Cladonia rangiferina* and *Comptonia asplenifolia* (= *C. peregrina*[1]).

The sand plains in Vermont[2]) are characterized by trees and shrubs of *Prunus cuneata*, *Pinus rigida*, *Quercus ilicifolia* (= *Q. nana* Sarg.), *Salix humilis*, clumps of the dominant grass *Andropogon nutans* var. *avenaceus* (= *Chrysopogon avenaceus* Michx.) with *Carex Houghtonii*, *Mühlenbergii*, *siccata* and *Fimbristylis capillaris* and many perennials, such as *Asclepias obtusifolia*, *Solidago puberula*, *Aster linariifolius*, *Lespedeza capitata*, *Lupinus perennis*, *Helianthemum majus*, *Viola arenaria* and *Spiranthes gracilis*.

## B. Lake District.

This phytogeographic district occupies the region west of Lake Champlain and the Ottawa River representing the drainage basin of the Great Lakes, with its northern boundary indicated approximately by the northern limit of white elm, *Ulmus americana*. It stands midway between the deciduous forests of the central eastern United States and the subarctic forest on the north and possesses enough of characteristic plants to separate it from the Maritime District on the east and the Prairie Region, which limits it on the west. Two areas are sufficiently distinct to merit recognition. These are know respectively, as the Interlacustrine and Adirondack areas.

### a) Interlacustrine Area.

This area comprises the country immediately surrounding the Great lakes and other glacial lakes west of the Ottawa River.

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1) BRITTON, WILTON E.: Vegetation of the North Haven sand Plains. Bulletin Torrey Botanical Club XXX: 571.

2) BRAINERD, EZRA, JONES, L. R. and EGGLESTON, W. W.: Flora of Vermont. Contributions to the Botany of Vermont VIII: 100. 1900.

## 1. The Forest Formations.

The forests of Quebec are extensive and approach those of northern and central Ontario in the number and distribution of the species. Except in the more southern districts the elms, maples and beeches occupy restricted areas, as they do further east, and the trees of Quebec with few exceptions are the trees of the New Brunswick area. The following additional species enter Quebec, but only along the Ottawa and St. Lawrence valleys.

Acer dasycarpum Ehrh. (= A. saccharinum L.).
Crataegus coccinea L.
Ulmus fulva Michx.
» racemosa Thomas (= U. Thomasi Sarg.).
Celtis occidentalis L.
Carya amara Nutt. (= Hicoria minima Marsh.).
Carya alba Nutt. (= H. ovata Mill.).
Carpinus caroliniana Walt.
Quercus alba L.
Populus monilifera Ait. (= P. deltoides Marsh.).
Juniperus virginiana L.

None of these trees are very abundant and the elms and the bitternut *Carya amara* (*Hicoria minima*) are the only ones that can be called common in Quebec.

*Floristic Character.* Owing to the position and extent of province of Ontario, its forests are not all of the same character and while in the north and northwest the species are identic with those found in Quebec, those in the south and southwestern peninsula are quite distinct and may be said to be a reproduction of the northern Ohio and Pennsylvania forest formations and hence this territory belongs to another phytogeographic region. Common to Ontario and Quebec[1]) are eighty-five species not found south of the Interlacustrine Area. The indigenous species include the following:

Anemone narcissiflora L.
Thalictrum alpinum L.
Ranunculus affinis R. Br. (= R. pedatifidus J. E. Smith).
» cardiophyllus Hook.
Arabis patula Graham (= A. Bourgovii Rydb.).
» retrofacta Graham.
Erysimum lanceolatum Pursh (= E. asperum DC.).
Vesicaria arctica Rich. (= Lesquerella arctica DC.).
Draba hirta L.
Thlaspi montanum L.
Cochlearia tridactylites Banks.
Arenaria arctica Stev.
Aster Lamarckianus Nees (= A. paniculatus Lam.).
Gnaphalium sylvaticum L.
Antennaria carpathica R. Br.
Senecio canus Hook.
Hieracium vulgatum Fries.
Crepis runcinata T. & G.
Cassiope (Andromeda) tetragona L.
Armeria vulgaris Willd.
Pentstemon gracilis Nutt.
Pedicularis palustris L.
Mertensia sibirica Don.
Gentiana acuta Michx.
Pleurogyne rotata Griseb.

1) DRUMMOND, A. T.: Some statistical Features of the Flora of Ontario and Quebec. Canadian Naturalist new ser. III: 429.

Astragalus labradoricus Hook. (= A. alpinus L.).
Dryas octopetala L.
» Drummondii Rich.
Rubus arcticus L.
Ribes oxyacanthoides L.
Saxifraga nivalis L.
Sium latifolium Bigel. (= S. cicutaefolium Gmel.).
Cornus suecica L.
Rumex acetosa L.
Elaeagnus argentea Pursh.
Salix vestita Pursh.
Echinodorus subulatus Engelm. (= E. tenellus Buchen.).
Alisma tenellum Mart.
Iris tridentata Pursh.
Eriophorum capitatum Host (= E. Scheuchzeri Hoppe).
Eriophorum russeolum Fries.
Carex ovata Rudge (= C. atratiformis Britton).
» bicolor All.
Elymus arenarius L.
Asplenium viride Huds.

The surface of the Laurentide country is of a mamillated character, its hills and peaks having been worn down by glacial action. The intervening depressions hold numerous small lakes and ponds. The more prominent elevations are covered with evergreens (Coniferous Forest Formation) chiefly *Pinus strobus*, *P. resinosa*, *Picea alba*. The sphagnum bogs (Bog Formation) consist of *Sphagnum cymbifolium*, *S. acutifolium*, *S. cuspidatum* surrounded by *Larix americana*, and on the rim of the depression with great regularity a circumarea of *Thuja occidentalis* associated most commonly with *Ledum latifolium*, *Alnus incana*, *Rhamnus alnifolius*, *Cornus stolonifera*. Encircling the latter circumarea and bounding the depression occur *Fraxinus sambucifolia*, *Ulmus americana*, *Betula lutea*, *Acer rubrum*, *A. spicatum*, *Ribes rubrum*, *R. lacustre*, *R. hirtellum*, and *R. nigrum*. The plants in the list below may be cited as truly Laurentian.

Ribes prostratum L'Her.
Aralia hispida Vent.
Spiraea tomentosa L.
Polygonum cilinode Michx.
Kalmia angustifolia L.
Pinus Banksiana Lamb. (= P. divaricata Ait.).
» rigida Mill.
Isoetes riparia Engelm.
Sphagnum squarrosum Pers.
Dicranum fulvum Hook.
» spurium Hedw.
Potamogeton Vaseyi Robbins
» spirillus Tuck.
Carex Houghtonii Torr.
» lenticularis Michx.
Asplenium ebeneum Ait. (= A. platyneuron Oakes).
Woodsia ilvensis R. Br.
Trichostomum (Leptotrichum) glaucescens Hedw.
Grimmia Olneyi Sulliv.
Hedwigia ciliata Eh h.
Bryum crudum Schreb. (= Webera cruda Schimp.).
Fontinalis antipyretica L. var. gigantea Sulliv.[1]).

*Extension and Kinds of Forest-Formations.* The whole face of the lake country north of Lake Superior is covered with a dense forest which is cha-

1) Macoun, John: The rarer Plants of Ontario. Transactions and Proceedings of the Botanical Society of Edinburgh XII: 300.

racterized by the predominance of certain northern types and the absence or rarity of trees more frequent farther south. An uninterrupted forest extended from Michigan through Wisconsin into Minnesota.

The forest formations in Northern Michigan, according to C. A. DAVIS[1]) are (1) the Deciduous Forest Formation which covered the better class of well-drained uplands, including the rock hills. The dominant species were Acer saccharum, Ulmus, Tilia, Fagus, in the south, Betula lutea, B. lenta in the north, with more or less mixture of conifers, especially Tsuga, Abies, Picea alba and Pinus strobus. (2) The Coniferous Forest Formation (Swamp Tree-Facies) which covered all of the undrained, or poorly drained flat lands, including the peat bogs and comprised Larix americana, Picea nigra and Thuja occidentalis with the occasional admixture of Pinus strobus, Abies, Picea alba, Fraxinus sambucifolia, Ulmus and Acer rubrum. (3) The Hemlock-White Spruce-Balsam-Facies was found on well drained flat lands and upon gentle slopes on the sides of the valleys. It had as fairly constant constituents Betula populifolia, B. lutea, Thuja occidentalis. (4) The White Pine-Facies was the type of forest in which Pinus strobus was dominant and confined to relatively small and disconnected areas of gravelly deposits and to partially covered rock outcrops. In open stands occur Pinus resinosa and P. Banksiana associated with Quercus coccinea and Acer rubrum.

Along the southern and southwestern border this forest merged into oak and jack pine "openings", and in places gave way to regular prairies: Mixed Forest Formation[2]). It is a mixed forest of *Pinus strobus* and hardwoods on all loam and clay lands, while the pineries on sand and loamy sand consisted of a mixture of *Pinus strobus* and *P. resinosa*. To the east and north of a line extending approximately from Lake Superior east to Green Bay the hemlock stands associated with the pines and hardwoods on all gravelly clay and loam soils. *Quercus rubra* is scattered through the forest and the absence of *Quercus alba* is noteworthy. South of this line however *Quercus alba* becomes abundant. Two kinds of forests may, therefore, be distinguished: the coniferous forest and the deciduous forest represented by the Acer-Fagus-Tsuga-facies. The undergrowth in the dense shade in the latter forest is scanty consisting of *Taxus canadensis*, *Mitchella repens*.

The basin of the Red River of the North represents the western or northwestern limit of many species of trees which constitute a large part of the eastern forests. It may be considered to be the western boundary of the Interlacustrine Area.

Among the trees which here reach their limit are Tilia americana, Acer saccharum, Acer rubrum, Juglans cinerea, Quercus alba, Q. macrocarpa, Q. tinctoria, Ostrya virginiana, Carpinus caroliniana, Betula lutea, Populus grandidentata, Pinus strobus, P. resinosa, Thuja occidentalis, Juniperus virginiana, Fraxinus americana, F. pubescens, F. sambucifolia, Ulmus fulva, U. racemosa. A few species of far northern range find in this district their southern or southwestern limit: Pinus Banksiana, Picea alba, Abies balsamea, Tsuga canadensis, Populus balsamifera.

Some of the eastern shrubs which make the undergrowth of the forests here attain their western limits: Vaccinium pennsylvanicum, V. corymbosum, Dirca palustris, Comptonia asplenifolia,

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1) *Report State Board of Geological Survey of Michigan. 1906: 191.*

2) AYRES, H. B.: Timber Conditions of the Pine Regions of Minnesota. 21st Report U. S. Geographical Survey Part V: 679.

*Xanthoxylum americanum, Celastrus scandens, Vitis cordifolia, Ampelopsis (Parthenocissus) quinquefolia,* Cornus circinata, C. sericea, C. candidissima, C. alternifolia[1]).

## 2. Rock- and Talus Formations.

*Rock Gorge Formation.* This formation is usually found on precipitous cliffs. The Dalles of the St. Croix and Wisconsin rivers may be taken as typic where rivers have worn deep gorges through the rocky strata. Ferns may be called the most characteristic feature in the St. Croix gorge. Growing in the clefts of the rocks is *Dryopteris (Aspidium) fragrans, Woodsia obtusa,* while on exposed faces occurs *Woodsia ilvensis* and on shaded cliffs *Cystopteris fragilis, Camptosorus rhizophyllus; Talinum teretifolium* occurs on the diabasic rocks with *Houstonia purpurea* and *Oxybaphus nyctagineus*[2]).

The cliff faces and damp, dark crannies of the Dalles of the Wisconsin show tufts of *Gymnostomum, Pellaea atropurpurea, Dryopteris fragrans* and on surfaces protected by overhanging shelves, sheets of the rare sword moss, *Bryoziphium norvegicum* (= *Eustichia norvegica*). The sandy summits of the cliffs show patches of Mosses (*Polytrichum, Dicranum, Leucobryum* and *Thelia Lescurii*). The walls of certain of the canyons are occupied by *Primula farinosa, Viola Selkirkii,* while rooted in the crevices of more exposed sandstone places grows *Potentilla fruticosa, Rhododendron lapponicum* and in similar more shaded situations near the water line *Sullivantia*[3]).

The dominant crevice herbs in general are: Campanula rotundifolia, Houstonia purpurea, Heuchera americana, Agrostis hyemalis, Arenaria stricta; the dominant crevice shrubs: Juniperus sabina, J. communis, Spiraea salicifolia, Rosa Woodsii, Diervilla trifida; the crevice trees are: Pinus strobus, P. Banksiana, Q. macrocarpa, Fraxinus americana, Populus tremuloides.

There are rock hills not connected with the present erosion of rivers. These hills have their peculiar vegetation. Stony Island is an outcrop of dolomitic Niagara (Silurian) limestone. The limestone is jointed and fractured and in the crevices occur mosses (*Ceratodon* and *Bryum*), while in the shallow soil on the rock face are *Potentilla arguta, Verbascum thapsus, Heuchera hispida, Poa compressa.* The opportunity for growth of shrubs eventually arrives and there appear *Prunus virginiana, Physocarpus opulifolius, Rhus radicans* and *typhina, Rosa humilis, Ptelea trifoliata, Pirus coronaria.* Later tree vegetation appears.

*Talus Formation.* Naturally the character of the talus depends upon the ledge from which it fell. Various types of vegetation occur on talus and form associations of herbaceous, shrubby or arboreal constituents. Space will permit the description of only one or two characteristic associations[4]).

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1) UPHAM, WARREN: Geographic Limits of Species of Plants in the Basin of the Red River of the North. Proceedings Boston Society of Natural History XXV: 140.

2) HILL, E. J.: Notes on the Flora of the St. Croix Region. Botanical Gazette XVI: 108, 126.

3) TRUE, RODNEY H.: Botanizing in the Dalles of the Wisconsin River. Plant World I: 81. March 1898.

4) See in this connection MACMILLAN, C.: Observations on the Distribution of Plants along

Cladonia gracilis Association. This occurs on shaded talus and is found typically along the north shore of Lake Superior. The face of the bluff above the talus is covered with species of Stereocaulon, Cetraria, Ramalina, Buellia, Usnea, Lecanora, Alectoria, Evernia and Pannaria, while the talus below is covered with a perfect maze of Cladonia gracilis, C. gracilis var. dilatata, C. cristatella, C. verticillata var. evoluta, C. furcata var. paradoxa, C. fimbriata var. apolepta, C. fimbriata var. subulata, C. fimbriata var. radiata, C. bacillaris, C. deformis, C. pyxidata, C. cenotea, C. coccifera, C. squamosa, C. caespiticia, C. uncialis, C. rangifera, C. sylvatica and C. alpestris with species of Stereocaulon, Peltigera stricta and Parmelia.

Cladonia rangifera Association. This is best developed on the east side of Hat Point near Grand Portage. Talus blocks occur here overgrown with coniferous trees and the whole talus block floor is covered with a rich growth of Cladonia rangifera, C. alpestris, C. sylvatica, C. uncialis, C. amaurocraea and Stereocaulon paschale with these in another place.

Lecanora Association. This occurs on exposed granitic boulders. The most constant elements of this association in Minnesota are Physcia caesia, Placodium cerinum, Placodium vitellinum, *Lecanora rubina*, *Lecanora cinerea*, *Lecanora xanthophana*, *Rinodina sophodes*, *Buellia* petraea.

Lecanora calcarea-contorta Association[1]. The lichens of this association have small thalli closely adnate, or even more or less hypolithic occuring on exposed limestone, viz., Placodium vitellinum var. aurellum, Lecanora subfusca, Lecanora calcarea var. contorta, Lecanora *privigna var. pruinosa*, *Rinodina Bischoffii*, *Endocarpon pusillum*, *Verrucaria nigrescens*, *Verrucaria* muralis.

## 3. Limnoplankton- and Lake-Formations.

*Plankton Formation.* The plankton of Lake Erie according to JULIA SNOW[2]) consists of the following algae; being much the same species as in Europe:

Confervoideae.

Stigeoclonium tenue Kg.
Aphanochaete repens A. Br.
Cladophora glomerata Kg.
Hormidium, 2 spec.

Siphophyceae.

Protosiphon botryoides Kg.

Protococcoideae.

Volvox globator Ehrb.
Eudorina elegans Ehrb.
Pandorina morum Bory.
Chlamydomonas, 3 spec.
Hydrodictyon utriculatum Roth.
Scenedesmus. 10 spec.
Coelastrum, 4 spec.
Pediastrum, 3 spec. (and 4 var.).
Staurogenia, 3 spec.
Kirchneriella, 2 spec. (and 2 var.).
Golenkinia fenestrata Schräd.
Ophiocytium capitatum Wolle.
Characium ambiguum A. Br.
Polyedrium, 3 spec.
Dictyosphaerium, 2 spec.
Tetraspora natans Kg.
Schizochlamys gelatinosus A. Br.
Botryococcus Braunii Kg.
Gloeocystis ampla Rabh.
Nephrocytium Agardhianum Nag.
Oocystis, 3 spec.

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shore at Lake of Woods. Minnesota Botanical Studies Bulletin Parts X and XI: 1007—1012; FINK, BRUCE: Some talus Cladonia Formations Botanical Gazette XXXV: 195—208 March 1903.

1) BRUCE FINK gives a minute and detailed classification of lichen associations too detailed for even brief mention here. See Minnesota Botanical Studies second ser. pages 1, 215, 277, 657 etc.

2) SNOW, JULIA W.: The plankton Algae of Lake Erie. Bulletin U. S. Fish Commission XXII 1902: 371—393.

Chodatella citriformis Snow.
Rhaphidium, 5 spec.
Silenastrum, 3 spec.
Dactylococcus infusionum Näg.
Stichococcus bacillaris Näg.
Pleurococcus, 2 spec.
Chlorella, 2 spec.
Botrydiopsis enensis Snow.
Chlorosphaera, 2 spec.
Scotinosphaera paradoxa Klebs.

Conjugatae.

Hyalotheca dissiliens Breh.
Onychonema laeve Nordst.
Sphaerozosma filiforme Rabh.
Closterium, 4 spec.
Closterium pronum Breb. (and var.).
Pleurotaenium trabecula Näg.
Cosmarium, 11 spec.
Euastrum, 2 spec.
Staurastrum, 5 spec.

Bacillariaceae.

Navicula limosa Kg.
Amphiprora ornata Bail.
Cymbella, 2 spec.
Encyonema prostratum Ralfs.
Cocconema, 2 spec.
Gomphonema, 3 spec.
Nitzchia sigmoidea Sm.
Campylodiscus cribrosus Sm.
Cymatopleura solea Bréb.
Surirella, 3 spec.
Synedra, 2 spec.
Fragilaria, 2 spec.
Asterionella formosa Hassal.
Tabellaria, 2 spec.
Melosira, 3 spec.
Orthosira orichalcea Sm.
Cyclotella, 3 spec.
Stephanodiscus Niagarae Ehr.

Schizophyceae.

Rivularia radians Thur. (and var.).
Mastigonema aerugineum Kirch.
Aphanizomenon flos-aquae Ralfs.
Anabaena flos-aquae Breb.
Plectonema mirabile Thur.
Oscillatoria, 6 spec.
Lyngbya Wallei Farlow.
Microcoleus anguiformis Haw.
Merismopedia, 4 spec.
Coleosphaerium roseum Snow.
Clathrocystis, 2 spec.
Gomphosphaeria aponina Kg.
Polycystis ichthyoblabe Kg.
Gloeocapsa fenestralis Kg.
Chroococcus, 3 spec.

The plankton of such lakes as Winnebago, Green, Eagle varies from season to season. Clathrocystis, and allied forms, Oscillaria are peculiar to shallow lakes. Gloeotricha, although a shallow lake form, also occurs in large numbers in deep lakes. Anabaena is the ordinary "bloom" in deep lakes, together with Ceratium. In Lake Winnebago, Asterionella gracillima, Cyclotella flocculosa, Synedra pulchella, S. acus var. delicatissima, Fragilaria, Stephanodiscus, Navicula, Surirella, Pleurosigma, Nassula form elements of the lake diatom flora[1]).

The plankton of western Lake Erie includes species of Merismopedia, Pediastrum, Sphaerozyga, Clathrocystis and many diatoms with occasional Desmidieae.

All other unattached species growing in quiet places form a second association (Lemna Association) viz., Utricularia vulgaris, Ceratophyllum demersum, Lemna trisulca, L. minor, Spirodela polyrhiza, Wolffia columbiana and with them masses of Mesocarpus, Spirogyra, Hydrodictyon, Oscillaria and Lyngbya. Microscopic epiphytic algae are also abundant here. This association is found well developed in western Lake Erie. — The plants forming a third association occupy by far the largest place in aquatic vegetation. The Characeae, Chara fragilis, C. coronata,

1) Marsh, C. Dwight: The Plankton of Lake Winnebago and Green Lake. Wisconsin Geological and Natural History Survey Bulletin XII. October 1903.

C. gymnophile var. Michauxia combine with Naias flexilis and Elodea canadensis to cover the bottom in water up to 10 or 12 feet in depth. Heteranthera graminea (= H. dubia), Vallisneria spiralis, Bidens Beckii, Myriophyllum spicatum, Ranunculus (Batrachium) divaricatus and Potamogeton pusillus, P. pectinatus grow to near the surface of the water. In this association (Vallisneria Association) must be included the attached submersed algae as Chaetophora, Cladophora, Oedogonium. — A fourth association (Nymphaea Association) forms a conspicuous feature in Lake Erie vegetation consisting of Nymphaea tuberosa, Nuphar (Nymphaea) advena, Nelumbium luteum, Polygonum Muhlenbergii, Potamogeton natans, P. pectinatus, P. pusillus, P. Robbinsii, P. lucens, P. amplifolius, together with Sagittaria graminea and variabilis, Typha, Phragmites in other places.

A fifth association is formed by the strand-horizon, where f. e. in the neighborhood of Sandusky Bog is found an assemblage of plants on the land side of the water-lily circumarea. It consists of Decodon (Nesaea) verticillatus, Pontederia cordata, Sagittaria, Cephalanthus occidentalis, *Alisma Plantago*, *Lysimachia (Naumburgia) thyrsiflora and Solanum Dulcamara*. This circumarea is succeeded shoreward by one consisting of Rosa carolina, Cornus stolonifera with Salix lucida. S. cordata, Lathyrus palustris, Scirpus americanus and other plants, which form a thicket that connects the aquatic formations with the forest on the higher ground.

The numcrous smaller lakes of the Interlacustrine Area are of glacial origin. They have been formed in three ways, (1) by the filling of a rocky basin; (2) by the formation of a dam of morainic material; (3) by the occupancy of a Kettle hole with water. Whatever their origin they show about the same stages of development until they finally disappear as lakes by being converted into sphagnum bogs by the encroachment of vegetation. The socalled Sister lakes in the Huron Valley in Michigan are of such a glacial origin. The largest of these lakes shows four fairly well defined vegetable horizons (or circumareas) occupying all the suitable lake bottom less than twenty feet under water [1]). Beginning with the innermost, they are: (1) a circumarea composed of *Potamogeton zosteraefolius*, which forms a dense tangled mat in water from eighteen to six feet in depth, with which is associated *Potamogeton lucens*; (2) a circumarea of *Nuphar advena* between thirty and seventy feet in width. This plant which is associated with *Potamogeton natans*, *Chara coronata*, *Dulichium spathaceum* and *Typha latifolia* grows as vigorously in water six feet deep as in water six inches deep. (3) A circumarea of *Carex* and *Sphagnum*, whose surface is practically at water level, extends landward from the water's edge from six to twenty five feet. The most abundant phanerogams are *Carex filiformis* and *Potentilla palustris*. (4) An circumarea of willows and poplars from ten to forty feet wide. The characteristic shrubs and trees are *Salix alba* var. *vitellina*, *S. lucida*, *S. myrtilloides*, *Populus tremuloides* and *Ulmus americana*.

*Swamp Formation.* This formation is typically represented at Cedar Point, Sandusky Bay. Here the tall reed vegetation passes into a wet swamp association where grow together in mixture *Calamagrostis canadensis*, carices (*C. Schweinitzii*, *stenolepis*, *stipata*, *laxiflora*, *comosa*, *lanuginosa*, *tribuloides*, *lupulina*, *vulpinoidea*), *Lobelia syphilitica*, *Penthorum sedoides*, *Lathyrus palustris*,

1) Reed, Howard S.: A Survey of the Huron River Valley. Botanical Gazette XXXIV: 125—139. August 1902.

*Mimulus ringens* willows (*Salixco rdata*, *lucida*, *amygdaloides*), *Onoclea sensibilis* and other ferns. The species are always somewhat mixed, but in each association some one tall species is clearly predominant. *Sagittaria rigida*, nearest the open channel gives place to *S. latifolia* mixed with *Zizania aquatica* and *Sparganium*. Following this a broad horizon of *Scirpus lacustris*, then *S. fluviatilis* mixed with *Scirpus lacustris*, which soon increases to a second broad circumarea mixed this time with some *Sparganium eurycarpum*. *Sparganium* in places is mixed with *Pontederia cordata*, *Sagittaria*; beyond the border of *Scirpus lacustris* which encircles this bed of *Sparganium* is a bed of *Typha latifolia* associated with *Naias*, *Dianthera*, *Sium*, *Asclepias incarnata*. Beyond the *Typha* is a vast stretch of *Phragmites communis* occupying shallow water or exposed muddy places.

The State of Michigan is characterized by the great number of deep hollows, slight depressions and flat areas in and upon which water accumulates and drains away very slowly. Thus lakes, swamps and bogs are numerous, the swamps and bogs arising by the encroachment of vegetation upon shallow lake basins. If the history of the vegetation extends back to the period when a boreal type of flora was prevalent in the region, then a sphagnum bog is found. If the filling of the lake basin is subsequent and began when a more modern flora influenced the character of the invasion then a true swamp area has arisen. We frequently find as at Mud lake in Washtenaw County a small area held by bog plants while the shores of the rest of the lake, south, southeast and northwest are occupied by a sedge mat in which *Typha latifolia*, *Sagittaria latifolia*, *Peltandra virginica*, *Symplocarpus foetidus* are most prominent. The bog areas of such lakes will be briefly discussed under bogs. The zonation of the swamp area of Mud Lake has been discribed by C. A. DAVIS [1]).

*Strand Formation.* The shore line of western lake Erie [2]) is either sand or sandstone and the characteristic plants are *Euphorbia polygonifolia*, *Triodia* (*Triplasis*) *purpurea*, *Elymus canadensis*, *Cenchrus tribuloides*, *Salix* spec., *Cakile* and *Polanisia graveolens*. Many rock plants are subject to wave action.

The plants of the drift, or middle beach, along Sandusky Bay and Lake Erie are such annuals as can endure the summer environment. Perennials and biennials are not found because of the destructive effect of ice and wave action during the winter. The characteristic species are *Cakile americana*, *Xanthium canadense*, *Strophostyles helvola* and the above named *Polanisia*, *Cenchrus* and *Euphorbia*.

Along the entire eastern shore of Lake Michigan, the dominant plant of the middle beach is Cakile americana (= C. edentula) associated with Corispermum hyssopifolium, Euphorbia polygonifolia. The flora of the upper beach is much richer than that of the middle beach [3]).

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1) In PEAT, Report State Board of the Geological Survey of Michigan 1906: 139.

2) PIETERS, A. J.: The Plants of western Lake Erie. U. S. Fish Commission Bulletin 1901: 57—79.

3) COWLES, H. C.: The ecological Relation of the Vegetation of the Sand Dunes of Lake Michigan. Botanical Gazette XXVII: 167—173.

Above the middle beach there is a strip characterized by the dominance of Elymus canadensis, then a strip of Geranium Robertianum, then a strip of Artemisia canadensis, and finally one of Cornus stolonifera scattered in which strips are Prunus pumila, Oenothera biennis, Lathyrus maritimus, Carduus Pitcheri, Agropyron dasystachyum, Populus balsamifera, Tanacetum huronense, Anemone multifida.

The strand along Lake of the Woods shows three subdivisions. The lower strand is occupied by plants which usually grow in strand pools: viz., Aphanizomenon flos-aquae, various Cyanophyceae and Chlorophyceae. *The mid strand vegetation consists of three types defined with* reference to adaptation to prevailing winds 1 Prunus Association, which consists of Prunus pumila, Lathyrus maritimus, Populus tremuloides, Juncus articulatus and Salix fluviatilis abundant as secondary plants. 2 *Cornus association*, where *Cornus Baileyi, C. sericea*, Convolvulus sepium, Oenothera biennis, Epilobium angustifolium are the prevalent plants. 3 Salix Association which is constituted by the commingling of Salix fluviatilis as dominant plant with Salix discolor, S. nigra, S. amygdaloides and Chenopodium album, Polygonum ramosissimum. The back strand is commonly marked at Lake of the Woods by a considerable rise in elevation. Here occur in various associations a great variety of herbaceous shrubby and arborescent species[1]).

*Dune Formation.* The shore of Lake Michigan between St. Joseph and Frankfort for a distance of 250 kilometers is fringed with a narrow belt of dunes which tend to close up the mouth of the rivers emptying into the lake with the formation of small lakes behind the dunes. Many of the dunes of northern Michigan are found on the top of steep bluffs and perhaps were formed when the lake water was at a higher level. The dune formers are plants adapted to such situations, viz., *Ammophila arenaria*, *Agropyrum dasystachyum*, *Elymus canadensis*, *Calamagrostis longifolia*, while certain shrubs are equally important: *Salix adenophylla*, *S. glaucophylla*, *Prunus pumila*, *Cornus stolonifera*, and two trees: *Populus monilifera* and *balsamifera*. These dune forming plants which give rise to various dune forms according to the species concerned are not the only tenants of the beach dunes. Most of the plants that grow on the upper beach are also frequently present on the dunes.

A second type of dunes are those which grow slowly. Here occur such plants as *Andropogon scoparius* which forms rounded hills of sand, *Arctostaphylos uva-ursi* and *Juniperus Sabina*, *Juniperus communis*, *Gaylussacia resinosa*, *Hudsonia tomentosa*, *Poa compressa* assist in holding the sand. The established, or fixed dunes result when after the sand has been captured by the above mentioned herbs and shrubs they are tenanted by, or culminate in forest vegetation.

This succession is typically represented at Cedar Point, Ohio, along Sandusky Bay. The Andropogon held dunes are invaded by Prunus virginiana, Juniperus virginiana, Ampelopsis quinquefolia, Arctostaphylos uva-ursi, Ptelea trifoliata, Tecoma radicans, Rhus aromatica and with such of secondary importance as Gleditschia triacanthos, Quercus tinctoria, Celastrus scandens, Prunus serotina, Vitis vulpina, Artemisia caudata, Rubus nigrobaccus, Asclepias syriaca, while Panicum virgatum, Elymus striatus, Andropogon scoparius are probably left-over plants from the preceding condition. One of the most noteworthy peculiarities of the Lake Erie dunes is the relatively large percentage of lianes which preserve the integrity of the dune against wind action.

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1) MACMILLAN, CONWAY: Observation on the Distribution of Plants along Shore at Lake of Woods, Minnesota Botanical Studies Bulletin 9, Parts X and XII: 949.

The basswood, *Tilia americana*, early encroaches on the dune areas and becomes a dominant and controlling element, associated later with *Populus monilifera*, *Sassafras*, *Quercus tinctoria*, *Fraxinus americana*, *Juglans cinerea* etc. Lianes are frequent: *Vitis cordifolia*, *Celastrus scandens*, *Rhus radicans*, *Ampelopsis* and *Smilax hispida*. Shrubs are abundant about the margin of the forest. Sometimes instead of the vegetation culminating in the deciduous forest, it becomes established in the form of a heath, which perhaps should be considered as a distinct Heath Formation. This is succeeded at Cedar Point by an oak forest. Such heaths consist of evergreen plants as *Juniperus virginiana*, *Arctostaphylos uva-ursi* with *Andropogon scoparius* and oaks.

The windward slope of the dunes has a different aspect and when one views them from the lakeside he sees a landscape in which coniferous trees predominate whereas a view from the land side shows a decided dominance of deciduous trees. The association of pines, *Pinus strobus*, is most prominent, at the south end of Lake Michigan *Pinus Banksiana* is more abundant, while at the north end *Pinus resinosa* is often as frequent as the white pine. *Thuja occidentalis* becomes a frequent member of these forests in the north as also *Abies balsamea*, and associated with the conifers are *Betula papyrifera*, *Tilia americana*, *Populus monilifera*, *Ostrya virginiana*.

Dunes are not abundantly developed at Lake of the Woods. A chain of islands exists called Isle aux Sables or islands of the sand hills. A list of plants collected here is given:

Juniperus communis L.
» sabina L.
Pinus Banksiana Lamb. (= P. divaricata Ait.).
» resinosa Ait.
Agrostis hiemalis Walt.
Calamagrostis canadensis Michx.
Elymus canadensis L.
Carex filiformis L.
» scoparia Schk.
Eleocharis palustris L.
Eleocharis tenuis Willd.
Juncus canadensis J. Gay.
» tenuis Willd.
Quercus macrocarpa Michx.
Salix discolor Muhl.
Betula glandulosa Michx.
Celtis occidentalis L.
Oxybaphus (Allionia) nyctaginea Michx.
Prunus pennsylvanica L. f.
Potentilla arguta Pursh.
Prunus pumila L.
Rubus strigosus Michx.
Sorbus sambucifolia Man. ed. 6 (= Pirus sitchensis Roem.).
Spiraea salicifolia L.
Lathyrus maritimus L.
Rhus radicans L.
Hudsonia tomentosa Nutt.
Oenothera (Onagra) biennis L.
Cornus sericea L. (= C. amomum Mill.).
Fraxinus americana L.
Sambucus racemosa L. (= S. pubens Michx.).
Campanula rotundifolia L.[1]).
Artemisia canadensis Michx.
» caudata Michx.

1) MACMILLAN, CONWAY: Observations on the Distributions of Plants along Shore at Lake of Woods. Minnesota Botanical Studies Bulletin 9, Parts X and XI: 989—993.

*Bluffs and Alluvial Plains.* There can be almost no other habitat in our climate, which imposes such severe conditions upon vegetation as an eroding clay bluff. The first vegetation to appear commonly consists of xerophytic herbs both annual and perennial. Among these are *Melilotus alba*, *Aster laevis*, *Equisetum hyemale*. Soon there develops a xerophytic thicket vegetation and this may be called the shrub stage of the captured cliff and among the dominant species are *Juniperus communis* and *virginiana*, *Salix glaucophylla*, *Cornus stolonifera*, *Shepherdia canadensis*, *Rhus typhina* and *glabra*. The succeeding tree stage is dominated by poplars [1]).

The river bluff formation in the Huron River Valley on till bluffs is marked by the presence of *Carya alba* (= *Hicoria ovata*), *C. tomentosa* (= *H. alba*), *C. microcarpa* (= *H. odorata*), *C. porcina* (= *H. glabra*), with which trees are associated *Quercus rubra* and *Q. alba*. On the sandy bluffs where the hickories and red oaks disappear are found *Quercus tinctoria*, *Q. alba* and in other places *Q. imbricaria*.

The flood plain of the Huron River Valley is occupied by a forest growth which consists of *Populus tremuloides* and *monilifera*, as the early pioneers followed by *Ulmus americana*, *U. fulva*, *Fraxinus pubescens*, *viridis*, *sambucifolia*, *Acer dasycarpum* [2]) and *rubrum*, *Platanus*, *Tilia*, *Juglans*, *Quercus macrocarpa* and *bicolor*. Along the tension line nearest the streams *Carpinus caroliniana* is common and in similar but drier situation *Ostrya virginiana* is found [3]).

## 4. Bog-Formation.

The sphagnum bog or moors (muskegs of the Minnesota woodsmen) may be regarded as glacial ponds, or lakes, in process of conversion to forest, and almost every imaginable transition may be found from open lakes with sandy beach lines continuous on all sides to solid masses of spruce and tamarack.

A description of one of these bogs as found in Minnesota follows. The center of the moor is ordinarily softer and more yielding than the edges. Sometimes open water exists here covered with Utricularia, Lemna trisulca or species of Potamogeton, Nuphar advena etc. Farther from the center Kalmia glauca and Andromeda polifolia with Pogonia ophioglossoides, Calopogon pulchellus various species of Carex and Eriophorum, Salix, Vaccinium and Sarracenia purpurea. Ledum latifolium grows in drier and more peripheral positions. Surrounding this association of plants are Picea alba or P. nigra, Larix americana and sundry species of Salix, Alnus incana and Betula pumila, B. glandulosa [4]).

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1) Cowles, Henry C.: The physiographic Ecology of Chicago and Vicinity. Botanical Gazette XXXI: 164—170.

2) Anmerkung des Herausgebers: Harshberger schreibt A. saccharinum gemäß dem Gebrauch von Sargent u. A. Da wir auf dem Nomenclatur-Standpunkt der Natürlichen Pflanzenfamilien und des deutschen Usus stehen, ist der nicht zweifelhafte Name A. dasycarpum belassen. (Drd.)

3) Brown, Forrest B. H.: A botanical Survey of the Huron River Valley III. The plant Societies of the Bayou at Ypsilanti. Botanical Gazette XL, p. 272. Oct. 1905.

4) MacMillan, Conway: On the Formation of circular Muskeags in tamarack Swamps. Bulletin Torrey Botanical Club XXXIII: 500—507 with plates.

Sphagnum atolls are formed by an increase in the size of a lake which had an open central lagoon of water fringed by vegetation. This ring of vegetation is detached and forms atolls occupying the center of the enlarged pond. The plants established on one of these atolls according to MAC MILLAN[1]), who has studied them, are Scheuchzeria palustris, Carex tenuiflora, Carex tenella, Carex intumescens, Eriophorum polystachyum and gracile, Pogonia ophioglossoides, Calopogon pulchellus, Lyonia (Chamaedaphne), Kalmia glauca, Andromeda, V. Oxycoccus, Menyanthes trifoliata, Sarracenia purpurea. The arrangement of species in the atoll was such that Menyanthes occupied the outer and inner edges, Kalmia occupied five distinct patches, while Sarracenia and Eriophorum sought the firmer substratum in the center. The other plants were sparingly represented.

Floating bogs are also occasionally met with in the lakes of the Interlacustrine Area and at times when stationary they constitute the anchored bogs, which subjected to a new environment become modified in consequence. Morasses develop from attached bogs when these occur in sheltered bays or coves. Two types of morasses are distinguished, wet and dry, and the association of species gives name to the morasses such as Menyanthes morass, Utricularia morass, Salix morass etc.[2]).

TRANSEAU[3]) has studied in a painstaking manner the bog associations of the Huron River Valley, and his description in general will apply to the bog areas, as found at Mud Lake and other localities in Michigan, as described by C. A. COOKE[4]) in a detailed manner, while discussing the distribution and origin of the peaty deposits throughout the state. — The first circumarea recognized by him next to the open water of the glacial lakes is the bog sedge circumarea (or association).

Here occur such dominant plants as Carex filiformis, C. oligosperma, Eleocharis palustris var. glaucescens, Eriophorum polystachyum while as secondary species occur Nephrodium thelypteris, Onoclea sensibilis, Juncus effusus, J. canadensis, Potentilla palustris, Salix myrtilloides, Dulichium spathaceum, Equisetum limosum, Bidens trichosperma var. tenuiloba, Menyanthes, Viola blanda and Eriophorum virginicum. Here and there among the sedges occur the forerunners of the shrub association. The rootstocks of Lyonia or Cassandra calyculata send up shoots and prepare the way for other plants. The bog near Oxford is without a central lagoon but it is occupied by the bog-sedge association where Carex oligosperma and Scheuchzeria palustris occur.

The bog-shrub circumarea in West Lake consists of *Carex filiformis* (most abundant), *Nephrodium*, *Eriophorum*, *Menyanthes*, *Potentilla*, with *Eleocharis palustris*, *Sagittaria latifolia*, *Carex tereticuscula*, *Salix myrtilloides*, *S. candida*, *Betula glandulosa*, *Vaccinium macrocarpon* and *Andromeda polifolia*. This circumarea about First Sister Lake is more irregular. *Lyonia calyculata* with the bog mosses *Sphagnum cymbifolium*, *S. subsecundum* and *S. recurvum* are in intimate association and occupy the area.

The associated species are the moss Aulacomnium palustre and such herbs as Drosera rotundifolia, Arethusa bulbosa, Habenaria lacera, Sarracenia purpurea, Pogonia ophioglossoides, Calopogon pulchellus, Viola blanda, Osmunda regalis, Campanula aparinoides, Scutellaria galericulata

1) MACMILLAN, CONWAY: Sphagnum Atolls in central Minnesota. Minnesota Botanical Studies Bulletin 9, Part I: 13.

2) Compare MACMILLAN, CONWAY: Observations on the Distribution of Plants along Shore at Lake of the Woods. Minnesota Botanical Studies Bulletin 9, Parts X and XI: 949—1022.

3) TRANSEAU, EDGAR N.: The Bogs and bog Flora of the Huron River Valley. Botanical Gazette XL: 351, 418—448. 1905; XLI: 17—42. 1906.

4) Report State Board of Geological Survey of Michigan 1906: 105—395.

and the shrubs Andromeda polifolia, Betula pumila, Vaccinium macrocarpon, V. oxycoccus, Pirus melanocarpa (= Aronia nigra) and Nemopanthes fascicularis.

Surrounding the bog north of Delhi in the Huron Valley is a circum-area on the floating margin of the bog substratum. *Typha latifolia* grows at the outer edge while *Lyonia calyculata*, 3 *Sphagnum*-species, *Carex filiformis*, *Eriophorum polystachyon* and *Salix myrtilloides* are the most frequent plants.

Associated with the above are Carex oligosperma, Menyanthes trifoliata, Comarum palustre, Elodea campanulata, Osmunda regalis, Onoclea sensibilis, Rumex britannica, Asclepias incarnata, Viola blanda, Cicuta bulbifera, Galium aparine, Scutellaria galericulata, Dulichium spathaceum and the mosses Hypnum cordifolium, H. Schreberi, Aulacomnium palustre.

Belonging to this circumarea, but almost distinct as an outer circumarea, are found an association of tall shrubs: *Vaccinium corymbosum*, *Gaylussacia resinosa*, *Pirus melanocarpa*, *Nemopanthes fascicularis*, *Betula glandulosa* and *Prunus serotina*.

The tamarack circumarea next succeeds on the outher drier edge of the bogs. *Larix americana* is found however as an occasional occupant of the inner circumarea. These trees in the outer edge of the bogs come to overshade the shrubs and form an almost pure growth, but with the trees are often associated *Nemopanthes*, *Pirus melanocarpa*, *Lyonia* (*Cassandra*), *Osmunda cinnamomea* and *regalis*, *Nephrodium spinulosum* var. *intermedium*, *N. cristatum*, such mosses as *Polytrichum juniperinum*, *Plagiothecium denticulatum*, *Thuidium recognitum*, *Aulacomnium palustre*, *Marchantia polymorpha*, *Sphagnum cymbifolium* and such funguses as *Boletinus porosus* and *Thelephora intybacea*.

## b) Adirondack Area.

The Adirondack mountains (compare Part. II, p. 104) are of considerable elevation somewhat rugged in outline. There are few lofty inaccessible cliffs but instead rounded easily scaled hills and mountain peaks, the roundness of which has undoubtedly been increased by the scouring action of the ice of the Glacial period, which overrode the highest peaks of these mountains. Mt. Tahawus (Mt. Marcy) is the highest peak 5,344 feet (1630 m) and Mt. McIntyre comes next 5,112 feet (1560 m). Fresh water lakes abound in this area, some of large size.

### 1. The Forest Formations.

*Deciduous Forest Formation.* The forest at the base of Mt. Tahawus along the Au Sable River and about the Au Sable lakes according to my observations consists of the following dominant species: *Betula lutea*, *Fagus americana*, *Tsuga canadensis*, *Acer saccharum*, *Thuja occidentalis*, *Pinus strobus*, *Abies balsamea*, *Betula papyrifera*, while as secondary trees are *Acer rubrum* and *pennsylvanicum*, *Populus tremuloides*, *Sorbus americana*, and beneath the latter *Viburnum lantanoides* and *Rubus odoratus*. Such occupy what are known in Adirondack phraseology as hardwood lands which are in general elevated flats and slopes where the deciduous-leaved trees are the characteristic

species. *Acer saccharum*, *Betula lutea* and *Fagus* attain their best development on these lands, while *Tsuga* is of inferior quality to that found on the moist soil of lower ground [1]).

Along the Au Sable River, near its source, in a gorge *Acer saccharum*, *Tsuga* and *Betula lutea* are preeminently first, while the beech seems to have a crown which never rises quite above that of the other trees mentioned (Tsuga-Fagus-Facies).

The herbaceous plants of the forest floor are Viola rotundifolia, Tiarella cordifolia, Medeola virginica, Mitchella repens, Maianthemum (Unifolium) canadense, Lycopodium lucidulum. Clintonia borealis, *Trillium erythrocarpum* (= *T. undulatum*), *Pyrola chlorantha*, *Oxalis acetosella*, *Aralia racemosa*, Dalibarda repens, Impatiens fulva, Streptopus amplexifolius. Taxus canadensis forms a secondary element in this Tsuga-Fagus-Facies [2]). Dryopteris noveboracensis forms extensive patches in the deep recesses of the forest.

*Mixed forests within the range of P. Strobus.* The shores of lower Au Sable Lake (plate IX) which are mountainous and steep, are covered with *Betula papyrifera* associated with *Abies balsamea* and *Populus tremuloides*. Near the upper end of this lake are *Sorbus americana*, *Picea nigra*, *Acer saccharum*, while *Thuja occidentalis* becomes more abundant and virtually supplants the paper birch *Betula papyrifera*. The perennials of the forest floor consists of *Clintonia borealis*, *Oxalis acetosella*, *Osmunda interrupta* and *cinnamomea*, *Chiogenes hispidula*, *Maianthemum canadense*, *Veratrum viride*. — The forest about Racquette Lake is a mixed one of broadleaf and coniferous trees, the latter predominating. Such are the spruce flats of the lumbermen, where the soil is fresh and deep with *Picea rubra* of medium height and diameter. These flats form the lower limit of *Acer saccharum* because it is common on higher ground. *Abies balsamea* is small.

The principal species are in the order in which they occur: Picea rubra, Betula lutea, Abies balsamea, Tsuga canadensis, Fagus americana, Acer saccharum, Pinus strobus (Picea-Betula-Facies). With these are associated Thuja occidentalis, Picea nigra, Larix americana, Pinus resinosa, Acer dasycarpum, Betula populifolia with scattered Fraxinus americana and Prunus serotina, Populus tremuloides and Prunus pennsylvanica are found on the burned over land, with an undergrowth in the primeval forest of *Viburnum lantanoides*, *Acer pennsylvanicum*, *Acer spicatum*. Here the characteristic swamp species are Picea rubra, Abies balsamea, Picea nigra, Pinus strobus, Larix americana, while on the gravelly knolls in the swamps occurs also Tsuga canadensis. Thuja occidentalis and Larix americana grow on the poorest drained land [3]).

Acer saccharum and Fagus americana have the advantage over Betula lutea on the better soils, because the latter is less tolerant of shade. The following list shows the relative degree

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1) PINCHOT, GIFFORD: The Adirondack Spruce 1898: 12.

2) HARSHBERGER, JOHN W.: The plant Formations of the Adirondack Mountains. Torreya V: 187—194. As data are lacking for the consideration of the algal vegetation of the lakes of the Adirondack Area, the writer has been unable to add any account of his own, but the student is referred for helpful details to a paper by G. E. STONE entitled, Flora of Lake Quinsigamond, Mass.

3) HOSMER, RALPH S. and BRUCE, EUGENE S.: A forest working Plan for Township 40. Bulletin 30 Division of Forestry. U. S. Department Agriculture 1901; GRAVES, HENRY S.: Practical Forestry in the Adirondacks-Bulletin 26. Division of Forestry. U. S. Department Agriculture 1899.

Forest Formations on Adirondack Mountains
surrounding Lower Au Sable Lake, Lake District — Adirondack Area.

of tolerance beginning with those that require the most light: Larix americana, Populus tremuloides, Prunus pennsylvanica, Pinus Strobus, Betula lutea, Acer rubrum, Abies balsamea, Picea rubra, Tsuga, Fagus and Acer saccharum. The species in general may be arranged according to edaphic requirements beginning with the most requiring: Prunus serotina, Acer saccharum, Fagus americana, Acer rubrum, Pinus strobus, Abies balsamea and Picea rubra. — As one ascends, the associations in some places consists of the deciduous species mentioned with Adiantum pedatum, Polystichum acrostichoides, Monotropa uniflora, Chiogenes hispidula, Clintonia borealis, Cornus canadensis, Panicularia elongata on the ground below.

*Coniferous forest Formation.* At 3,600 feet (below 1200 m) especially on the southern flanks of Mt. Tahawus the coniferous forest formation consists of *Picea rubra* with *Betula lutea*, *lenta* and *Sorbus americana*. *Abies balsamea*, *Thuja occidentalis* and *Veratrum viride* occurs on the forest floor, with *Vaccinium canadense*, *Lycopodium annotinum* and *lucidulum*, *Aster acuminatus*, *Solidago flexicaulis*, *Coptis*, *Linnaea*, *Streptopus amplexifolius*. These southern slopes are the spruce slopes, according to the designation of lumbermen, because *Picea rubra* is prominent. The absence of any *Acer* and *Viburnum lantanoides* is due to elevation and is noteworthy. *Abies balsamea* on an elevated saddle of the mountain forms a pure association with shrubby and herbaceous companions (Abies-Facies), and in open swampy places surrounded by the balsam occur *Osmunda cinnamomea* and *Veratrum viride*. The hemlock *Tsuga canadensis* forms pure associations (Tsuga-Faeies), as on the ridges at the foot of Giant Mountain. Here the beech and the maples (*Acer*) are subordinate species with a few spruce trees (*Picea*) intermixed.

The herbaceous undergrowth is typic of such forests consisting of Linnaea borealis in mats, Mitchella repens in mats, Cornus canadensis in patches, Pyrola chlorantha, Oxalis acetosella, Clintonia borealis, Goodyera (Peramium) repens, Medeola virginica, Pyrola secunda, Viola rotundifolia, Chimaphila umbellata, Gaultheria procumbens, Coptis trifolia, Maianthemum (Unifolium) canadense, Cypripedium acaule, Habenaria (Lysias) orbiculata, Lycopodium lucidulum. This is the same association of species under the hemlocks that one finds in southern Pennsylvania with the addition however in the Adirondacks of Linnaea borealis, Clintonia borealis, Coptis trifolia.

In more elevated situations, the botanist finds on Giant Mountain a Picea-Abies-Facies, associated with three birches, *Acer rubrum*, *Ribes prostratum*, *Rubus strigosus*, and with a few ferns (*Dicksonia punctilobula!*) abundant. — *Pinus resinosa* in a few localities, as on the southwest slopes of Baxter Mountain (2,400 feet = 732 m), forms an association (Pinus resinosa-Facies) sometimes with *Pinus strobus* interjected: *Juniperus communis* together with *Vaccinium pennsylvanicum* and *V. canadense*, *Pteris aquilina* form an association on rocks (Juniperus-Vaccinium-Association). The two pines dominate the southwest slopes of Mt. Baxter down to the lowest ridges where *Quercus rubra, Acer pennsylvanicum* and *Tsuga canadensis* are in association.

## 2. Alpine Summits, Bogs and Rocks.

The Krummholz or dwarf timber (Dwarf Tree Formation) is reached at 5,000 feet (1,530 m) on Mt. Tahawus. Here *Abies balsamea* is about five feet high with its base covered by *Hypnum splendens*, *crista-castrensis*, *Dicranum*

with *Linnaea*, *Chiogenes*, *Cornus canadensis*, while *Vaccinium canadense* and *Sorbus americana* are prominent shrubs. At 1,550 meters, trees are only 1—2 feet high and disappear entirely on entering into the alpine formations, being replaced on exposed places by *Ledum latifolium*, *Vaccinium uliginosum*, *V. caespitosum* (Vaccinium-Ledum-Association), the Empetrum-Association and the Alnus-Association formed by *Alnus viridis* together with *Spiraea salicifolia* in sheltered places, *Gentiana linearis*, *Veratrum viride*, *Linnaea borealis*.

The plants credited by CHARLES H. PECK to the summit of Mt. Tahawus are given in the accompanying list with those collected by the writer[1]) on the bare top marked by an asterisk (*) and those below the intermediate summit by a dagger (†).

*Coptis trifolia Salisb.
*Viola blanda Willd.
*Arenaria groenlandica Spreng.
Stellaria (Alsine) borealis Bigel.
*Oxalis acetosella L.
*Potentilla (Sibbaldiopsis) tridentata Ait.
*Rubus strigosus Michx.
» triflorus Richards (= R. americanus Pers.).
*Sorbus sambucifolia Man. ed. 6 (= P. sitchensis Roem).
*Spiraea salicifolia L.
†Amelanchier oligocarpa Roem.
*Ribes prostratum L'Her.
†Epilobium angustifolium L.
*Houstonia caerulea L.
Solidago macrophylla Pursh.
*Solidago virga aurea var. alpina Bigel. (= Solidago alpestris W. & K.).
Prenanthes (Nabalus) nana Torr.
* » ( » ) Bootii Gray.
*Vaccinium caespitosum Michx.
* » pennsylvanicum Lam.
* » pennsylvanicum var. angustifolium Gray.
* » uliginosum L.
* » oxycoccus L.
*Chiogenes hispidula T. & G.
*Lyonia (Cassandra) calyculata L.
Drosera rotundifolia L.
*Cornus canadensis L.
*Linnaea borealis L.
Lonicera caerulea L.
Melampyrum lineare Lam. (= M. americanum Michx.).
*Trientalis americana Pursh.
Chelone glabra L.
*Diapensia lapponica L.
*Ledum latifolium Ait.
*Kalmia glauca Ait.
*Rhododendron lapponicum L.
*Rhinanthus crista-galli L.
Gentiana linearis Froel.
*Empetrum nigrum L.
*Betula glandulosa Michx.
† » papyrifera Marsh.
*Alnus viridis DC.
*Salix uva-ursi Pursh.
Picea alba Link (= Picea canadensis Mill.).
Picea nigra (= P. brevifolia Peck).
*Abies balsamea Mill.
Juniperus communis var. alpina Gaud. (= Juniperus nana Willd.).
Habenaria dilatata Pursh.
Streptopus roseus Michx.
† » amplexifolius DC.
Clintonia borealis Raf.

1) The ascent was made with Prof. Dr. O. DRUDE on August 26, 1904. See also PECK, CHARLES H.: Plants on the Summit of Mt. Marcy. Bulletin New York State Museum V: 657.

*Maianthemum canadense Desf.
*Veratrum viride Ait.
Juncus trifidus L.
» filiformis L.
†Luzula parviflora Ehrh.
Scirpus caespitosus L.
*Eriophorum vaginatum Am. auth. (= E. callithrix Cham.).
Carex scirpoidea Michx.
» canescens L.
» brunnescens Poir.
» trisperma Dew.
» magellanica Lam.
» sterilis Willd.
» Bigelovii Torr.
» pauciflora Lightf.
Agrostis rubra L.
Calamagrostis canadensis Michx.
» breviseta Scribn.
Stipa Macounii Scribn.
Poa laxa Haenke.
Deschampsia flexuosa Trin.
Hierochloë alpina Sw.
Phleum pratense L.
Cinna latifolia Trev.
» arundinacea L.
†Nephrodium (Dryopteris) spinulosum Desv.
Phegopteris polypodioides Fée.
*Lycopodium selago L.
† » annotinum L.
† » annotinum L. var. pungens Desv.
† » clavatum L.

A singular lichen *Thamnolia vermicularis* attracts attention by its pure white color and its cylindric, hollow, sharp pointed podetia 2—4 inches long growing among mosses and on the thin soil of the mountain tops in a sterile condition. It is more plentiful according to PECK on Mt. McIntyre than on Mt. Tahawus. *Lonicera caerulea* almost ascends to the top of the mountain. It occurs behind the sheltering rocks but a short distance south of the signal station. *Carex Bigelovii* is the only sedge on the highest part of the mountain.

*Alpine Bog Formation.* Two small marshy areas form a part of the open summit. One is a decided depression in the northeast slope; the other is on the eastern slope and is much nearer the top of the mountain.

Here were found by me Kalmia glauca, Ledum latifolium, Vaccinium oxycoccus, Eriophorum vaginatum, Veratrum viride, Vaccinium uliginosum and several species of Carex.

*Bare Rock Summit Formation.* The summits of lower mountains, Mt. Hopkins (3,136 feet = 955 m) for example, are not above timber-line but frequently they are bare owing to rock exposures. On this mountain a smooth rock surface occurs in the broken areas of which *Potentilla tridentata* grows (Potentilla-Association) with Vaccinium uliginosum-Association and Alnus-Association. *Vaccinium pennsylvanicum*, *Vaccinium pennsylvanicum* var. *angustifolium*, *Vaccinium canadense* are found along the edge of the forest consisting at this elevation of *Picea nigra*, *Abies balsamea*, *Betula papyrifera*, *B. lenta* etc. that reach quite to the top of the mountain.

Giant Mountain (4,622 feet = 1410 m) is not bare at the summit except where shelving rocks occur. Here were found by me Ledum latifolium, Arenaria groenlandica, Marchantia polymorpha (in abundance), Agrostis rubra, Vaccinium pennsylvanicum, Linnaea borealis, Cornus canadensis.

An interesting Rock Gorge Formation is typically developed in the Au Sable Chasm in the northern part of the Adirondack Area. The Au Sable River runs through a rock gorge withalmost straight sides and a few overhanging shelves. Along the crest of the precipices and in the gorge,

according to my observations, are found Pinus resinosa, Betula papyrifera, Tsuga canadensis, Thuja occidentalis, Betula lutea, Acer rubrum, while somewhat back from the gorge together with the above mentioned trees, Pinus strobus, Betula populifolia, Quercus rubra, Q. alba, Q. tinctoria beneath which occur Amelanchier canadensis, Hamamelis virginiana, Gaylussacia resinosa. The rock crevices show Campanula rotundifolia var. Langsdorfiana, Polypodium vulgare, Aralia racemosa, Rubus odoratus, Ribes rotundifolia and on the shelves, clumps of Rubus strigosus.

*Conclusion.* The southward extension of the coniferous forest of which the Adirondack Mountains form a part is found following the plateau region in central, and southern New York and northern and western central Pennsylvania (west of the mountains) about as far south as the 40° of north latitude. The coniferous forest belt only extends into the southeastern quarter of Warren County Pennsylvania; the northern and western portions lying beyond the Alleghany River show oak, chestnut, hickory [1]). Much the same association of species is found in this forest, as in the Adirondack mountain forests. *Pinus Strobus* is dominant here. Upon the best soils various hardwoods grew with it. For example at a place in Lycoming County, Pennsylvania near Otter Run an astonishingly large number of kinds of trees occurred on a fresh sandy loam in mixture with *Pinus strobus* [2]).

Upon an area of not more than twenty acres the following species were growing in natural forest: Liriodendron tulipifera, Tilia americana, Acer saccharum, Acer rubrum, Prunus pennsylvanica, Prunus serotina, Nyssa sylvatica, Fraxinus americana, Ulmus fulva, Juglans cinerea, Carya amara, alba and porcina (= Hicoria minima, ovata and glabra), Quercus alba, Q. Prinos, Q. rubra, Q. tinctoria, Castanea dentata, Fagus americana, Ostrya virginiana, Carpinus caroliniana, Betula papyrifera, Betula lutea, B. lenta, Populus tremuloides, P. grandidentata, Pinus resinosa, P. rigida, P. virginiana, Tsuga canadensis[2]). Pinus Strobus and hemlock are the prevailing trees mingled with Acer saccharum, beech and species of Betula, while the herbs are such as grow beneath the shade of the dominant forest trees most of which have been mentioned above. Although we have treated the Pocono plateau as part of the northern Appalachians, yet with some propriety its flora may be considered to be closely similar to that of the great coniferous of the St. Lawrence—Great Lake Region.

## 2. Atlantic-Gulf Coastal Region.

The plant formations, which together form the vegetation of the great Atlantic coastal plain, occupy soil of a comparatively recent geologic origin, when the coastal plain was raised permanently above sea level, for since the beginning of Cretaceous time, this country has passed through several vicissitudes of history, at times being dry land, as it is now, and at times sea bottom. So the shore of the sea has oscillated slowly back and forth across this part of the Atlantic plain and gravels, sand and clays have been deposited. Three distinct physiographic areas are recognizable: the elevated plain; the coastal marshes and the

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1) The counties of Pennsylvania which together form the hemlock-white pine belt are Bradford, Tioga, Potter, McKean, Warren, Forest, Elk, Cameron, Jefferson, Clearfield, Indiana, Cambria, Somerset and parts of Armstrong, Clinton, Lycoming, Sullivan, while Centre, Susquehanna, Lackawanna, parts of Wayne and Monroe were noted for their hemlock woods.

2) PINCHOT, GIFFORD and GRAVES, HENRY S.: The White Pine 1896: 30—31.

coastal strand, consisting of sand piled up by wave and wind action. The flora, as a consequence, has adapted itself to the edaphic conditions of such a region, and floristically considered it is peculiarly American composed of plants that have passed through the vicissitudes of the physiographic changes with the admixture of a small contingent of immigrant plants.

## A. Northern Pine Barren-Strand District.

This phytogeographic district may be said to extend from the mouth of the Chesapeake Bay northward and northeastward to the extremity of Long Island contributing a few of its floral elements to the vegetation of Block Island, Marthas Vineyard, Nantucket and Rhode Island[1]). It is coincident with the soil formations that compose the Tertiary coastal plain east of the Archaean rocks, the edge of which is called the fall line, that represents the eastern limit of the Piedmont plateau.

### 1. Salt Strand-, Beach- and Dune Formations.

*Strand Formation.* The strand of Long Island may be looked upon as a continuation of that of New Jersey. The presence of such sand beach plants as *Ammophila arenaria*, *Salsola Kali*, *Arenaria peploides*, *Cakile americana*, *Hudsonia tomentosa*, *Solidago sempervirens*, *Myrica carolinensis* (= *M. cerifera* Gray's Manual), *Baccharis halimifolia*, *Iva frutescens*, and such salt marsh plants as *Spergularia* (*Tissa*) *marina*, *rubra*, *Salicornia* (3 sp.), *Kosteletzkya virginica*, *Hibiscus moscheutos*, *Discopleura capillacea*, *Panicum virgatum*, *Spartina stricta* and *patens* etc. emphasizes the similarity of the strand floras of Long Island and New Jersey (see in this chapter § A. b. p. 381). The north shore of Long Island along the Sound is generally rocky. The steep shore lines are piles of glacial drift full of clay, siliceous sand, gravel and boulders of varying size. Just above the reach of the ordinary tides these beaches are partially covered with *Spartina juncea* interspersed with *Rhus radicans* (= *R. toxicodendron* of some authors); *Juniperus virginiana*, *Myrica carolinensis*, *Prunus maritima* are the only woody plants found here. On the more barren places back from the spray are tufts of *Hudsonia tomentosa*, *Cladonia rangiferina*[2]).

The strand flora of New Jersey is typically developed on the sandy sea islands or peninsulas separated from the mainland by open bays or extensive salt marshes. If we contrast the character of the flora on the northern and southern shore of New Jersey[3]), we find that the formations on Barnegat beach,

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1) See in this connection HARPER, ROLAND M.: Further Remarks on the coastal plain Plants of New England, their History and Distribution. Rhodora VIII: 27 Feb. 1906 and his preliminary paper Rhodora VII: April 1905 on the same subject.

2) DAVENPORT, C. B.: The Fauna and Flora about Cold Spring Harbor, L. I. Science new ser. VIII: 688.

3) HARSHBERGER, JOHN W.: An ecological Study of the New Jersey Strand Flora. Proceedings Academy Natural Sciences of Philadelphia 1900: 623—671; Additional Observations on the strand Flora of New Jersey. do. 1902: 642—669.

for example, are usually open while those on Wildwood beach are closed and have culminated in the forest type of vegetation. This argues for a greater age of the strand flora of Wildwood, as compared with that, for example, at Sea Side Park in the north. This conclusion is substantiated by the fact that the bays behind the sandy sea islands are converted into salt marshes in the south, while in the north they are wide and open bays of brackish or salt water. Physiographically and botanically the coast line from Bay Head south to Ocean City is younger than the coast south of the latter place extending to Cape May.

*Beach Formation.* The beach formation exists at the several places investigated in several modifications of the typic one, which exists at Seaside Park, N. J. The lower beach is limited by the reach of the higher tides and is marked by the constant shifting and grinding of the particles of sand against each other by wave action. The middle beach, where driftwood collects, supports a considerable number of herbaceous annuals, which show in a striking way their adaptation to unpropitious surroundings. The most abundant plant of the middle beach in all the localities studied is *Cakile americana* (= *C. edentula*). Associated with this succulent is also another, *Arenaria peploides*, which grow in clumps, and is of a dark-green color with thick, fleshy leaves. It forms the so-called annual dunes which are piled up around its succulent stems, remaining as small hillocks of sand, through which this plant protrudes, until autumn, when upon the death of the sand-binder the sand is again caught up by the wind and carried away. *Cakile* is also instrumental in catching the sand and holding it in the form of embryonic dunes. These two plants are the only ones found commonly on Barnegat Beach at Sea Side Park.

At South Atlantic City, in addition to *Cakile* and *Arenaria* which are also found there, grow *Salsola kali*, *Euphorbia polygonifolia* and *Cenchrus tribuloides*. *Salsola* is extremely xerophytic with succulent stem and leaves and spinous habit. *Euphorbia*, a prostrate herb, possesses latex, which is probably instrumental in reducing transpiration. *Cenchrus*, of annual habit, depends upon its prickly fruit for its distribution. It is abundant, as a character plant, at South Atlantic City, along the dune faces in the strip of succulents, and also as a component of the flora in the strips more distinctly removed from the ocean front. This is true of this grass both at Ocean City and Wildwood, where it is not conspicuous by its presence on the middle beach.

The most interesting distribution of plants is met at Wildwood. Here the beach is extremely flat and very wide, trending to the northeast, where apparently it is widest. The lower beach consists of sand, packing well together, and when wet presenting a hard, firm, floor-like surface. Just above the ordinary limit of high tide are little hummocks of sand held in place by the stalks of grasses and other herbaceous plants which have been washed up by tidal action. This area of loose sand is succeeded by a line of more elevated sand bordering a tidal depression inside it. Upon this low ridge of

sand *Salsola kali* grows in the greatest abundance, and an inspection indicates that the tide must flow at times between the *Salsola* patches. On the far side of the tidal pool are found, in association with isolated clumps of the marram grass, *Ammophila arenaria*, growths of an annual *Atriplex arenaria*. Proceeding up the beach in a straight line, a wind-swept area tenanted by marram grass and isolated plants of *Xanthium* (*echinatum*), *Euphorbia*, *Salsola kali* (not as a character plant), *Sesuvium maritimum* and *Strophostyles helvola* are passed. The only area which merits the name Ammophila-Strip occupies the portion of the beach adjoining that described, but the sand grass, *Ammophila arenaria*, although abundant here, hardly can be called a zonal plant at present, although it has commenced to build a frontal dune, which when raised above the level of the beach (a stage which it has not yet reached) may separate the middle beach from the upper beach sufficiently to merit the application of the zonal name to this area of the Wildwood sea-strand. The sand grass growing here was found in full flower associated with *Arenaria peploides*, gathering the sand about it, and *Strophostyles helvola*, creeping out as a radiant plant in all directions. The *Oenothera humifusa*-strip or upper beach, comprises the hollow place in front of the low frontal dune and the seaward face of the dune itself. Here grow in perfect harmony *Gerardia purpurea*, *Strophostyles helvola* with narrower leaflets, *Solidago sempervirens* with thick leaves, which is found on the lee face of the sea dunes farther northward, *Erigeron canadensis* and *Oenothera humifusa* — the plant which gives name to this interesting assemblage of species. The latter is chosen as a character plant, because Cape May county represents the northern limit of its distribution, which extends to Florida. This species is essentially southern in its range, occurring on the sea beaches of the southern states. Its presence is proof of the mild climate of Wildwood. The lower face of the dune here supports *Lactuca canadensis* and life-everlasting, *Anaphalis margaritacea*.

*Dune Formation.* Ammophila Strip. Upon the top and lee side of the sea dune at Sea Side Park, which extends in some places uninterruptedly there for a distance of half a mile, with a uniform height of about 15 feet, and at a uniform distance from the ocean front, grows the best of all sand-binders, *Ammophila arenaria*. Associated in a remarkable ecologic way with this grass is the sand pea, *Lathyrus maritimus*, which flourishes with it on the dune summit and supplies the grass by means of its tubercles with nitrogenous material which stimulates the growth of the marran grass, so that it makes a denser growth.

Myrica Strip. Just behind the high dune which faces the ocean and on its lee slope, protected by the top of the dune, is met an extensive belt of *Myrica carolinensis* which occurs normally at Sea Side Park, South Atlantic City and Ocean City, but is absent at Wildwood. It occurs typically at Seaside Park and also clearly defined at South Atlantic City, but at Ocean City it is broken up in two parallel areas behind the second and third series of dunes. Normally it should occur behind the first or frontal dune. Isolated

specimens of *Myrica* are found in the thicket formation, but as far as inspection showed it does not grow as a zonal plant. Associated with the waxberry bushes at Sea Side Park is the ubiquitous sand grass (*Ammophila*), an occasional golden-rod (*Solidago sempervirens*) and a prostrate growth of *Euphorbia polygonifolia*, but that is all. At Ocean City, *Strophostyles helvola*, *Panicum virgatum*, *Baccharis halimifolia*, *Rhus radicans* are mixed together by reason of the parallelism of the three dunes which occur there, and *Myrica*, therefore, becomes an element of the dune complex.

Hudsonia Strip (the Dune Complex). This strip is of especial interest. The topography is kaleidoscopic. The dunes are constantly changing their shape, being blown away on one side and built up on the other. The hollows between them are filled up and new valleys are scooped out by the resistless action of the wind. This is true of this belt along the entire New Jersey coast, where it is a dominant feature of the landscape, but the change is not so rapid in some places as in others. Some of the dune complexes change very slowly, others more rapidly; some, it may be, have become stationary. At Sea Side Park, the dune complex extends from the limits of the Myrica-Strip already defined to the Juniper-Strip of the typic thicket formation. At South Atlantic City it does not exist; at Ocean City it is an area of established dunes clothed with a variety of plants; at Wildwood it is a narrow area of a low frontal dune and a hollow immediately behind it, encroached upon by tree growth, and is, therefore, not clearly demarcated at either of the places last mentioned.

At Sea Side Park, where it typically exists, there is not an established series of dunes, but the change is a slow one, motion being arrested by the character plant, *Hudsonia tomentosa*, which forms clumps or cespitose clusters closely set together on the top and sometimes the slopes of the slowly moving dunes. Associated with this low growing perennial herb are found *Solidago sempervirens*, *Rhus radicans*, trailing over the ground and with an etiolated appearance, expressive of its struggle for supremacy. *Linum medium*, *Lechea maritima* and others, such as *Ampelopsis*, are occasional intruders on the more established dunes [1]).

Upon a transversely placed dune exist isolated trees of the following species in considerable numbers, but nowhere growing together, except it may be in companies of twos or threes, usually, however, standing alone: *Quercus ilicifolia*, is a small tree of dense growth; *Ilex opaca* is strong-growing and dark green in color; *Quercus phellos*, the willow oak, forms a dwarf tree about four feet high; *Vaccinium corymbosum*, with smooth leaves, and *V. atrococcum*, with densely pubescent leaves and gnarled form, both loaded with berries, were found to exist here, with *Kalmia angustifolia*, and *Rubus canadensis*, trailing

1) Prunus maritima L., the beach plum, forms by its upward growth small dunes, comparatively steep. It usually grows in isolated patches on the slopes or summits of the dunes, near the center or inside margin of the dune complex.

at their base. *Pinus rigida* also is a component element of the transverse dune complex, growing with the sassafras on the dune slopes and drier dune hollows. *Juniperus virginiana* is also abundant here. The landscape has, therefore, somewhat of a park-like aspect.

The dune complex (not Hudsonia Strip) at Ocean City is a succession of dunes and dune hollows. Upon the top of the dunes and covering their slopes to some extent the marram grass, *Ammophila*, has almost full sway, but occasionally *Sieglingia purpurea*, *Strophostyles* and *Solidago sempervirens* are associated with the above mentioned grass. The dune complex at Wildwood is a narrow belt (50 feet wide) of established dunes. It might be said to belong to the thicket formation, but for the fact that it is open. Upon the low dune, 4 or 5 feet high, flourish *Rosa carolina*, *Rhus radicans*, *Sieglingia purpurea*, *Phytolacca decandra*, and dead, badly wind-swept cedar trees. Immediately behind the dune front *Ampelopsis*, *Panicum virgatum*, *Andropogon virginicus*, in clumps, and *Monarda punctata* make up the list of conspicuous plants of the narrow dune complex of Wildwood Beach. Several isolated trees, *Juniperus virginiana*, *Quercus obtusiloba* (= *Q. minor*) of dwarf growth stand here, and form the vanguard of the tree growth which so completely covers the higher portion of Five-mile Beach.

Occupying zonally about the same position as the Myrica association of New Jersey there is found back of a second series of dunes and reaching to the forest in Delaware an area covered by a thicket. It is a wilderness of Baptisia tinctoria, Rubus villosus, R. cuneifolius, R. canadensis. In clumps or singly are Juniperus virginiana, Diospyros virginiana, Pinus virginiana, P. rigida, Quercus falcata, Prunus maritima, P. pennsylvanica, Myrica carolinensis, Rhus copallina, Helianthemum canadense, Sassafras officinale, Rosa humilis. Ilex opaca and among the herbs, rare or frequent, Solidago juncea, S. Canadensis, Eupatorium album, E. hyssopifolium, Aster ericoides, Ascyrum Crux-Andreae, Asclepias tuberosa, Trichostema dichotomum, Andropogon virginicus (important next to Ammophila arenaria) the last associated with Agrostis alba, A. hyemalis, Eragrostis pectinacea, Panicum sphaerocarpum, P. viscidum (= P. scoparium), Poa compressa. Lianes are almost entirely absent, but Cladonia rangiferina is abundant in patches.

On Seven Mile Beach the Myrica-Strip is absent in the hollows back of this dune. Its place is taken by the social groups of Strophostyles which forms dark-green mats. In the deeper hollows, *Gerardia maritima* and *Euphorbia polygonifolia* may be called character plants. The dune complex is undulating with rising hills of sand, covered on the seaward side by *Strophostyles* and on the landward slope are *Solidago sempervirens* and occasional clumps of *Myrica carolinensis*, not dominant; *Oenothera humifusa*, *Baccharis halimifolia* and *Andropogon virginicus*. Across the area controlled by these herbaceous plants, the barren wind-swept strip is reached upon which no vegetation grows except the marram grass (*Ammophila*), an occasional red cedar, and as rare plants, *Phytolacca decandra* and *Euphorbia polygonifolia*. Dead trees stand up out of the sand over this zone, which is about six hundred feet wide, a forest graveyard. The forest which is being destroyed consists of *Juniperus virginiana*, *Ilex opaca*, *Nyssa sylvatica*, *Prunus serotina*, *Quercus lyrata*, *Celtis occidentalis*, *Quercus phellos*, *Acer rubrum*, *Diospyros*

*virginiana*, *Pinus rigida*, *Morus rubra* (see fig. 23), while as lianes may be mentioned *Ampelopsis*, *Vitis labrusca* and *aestivalis*, *Tecoma radicans*, which reminds one of the dunes on the seashore of eastern Virginia, where the trumpet creeper abounds with *Smilax rotundifolia*. As the sand blows in about the trees, these lianes are covered up with the trees until the tops of the trees only are exposed. The lianes then take root and spread out in all directions circumferentially a distance of many feet from the tree which, now dead, formerly supported them.

The presence of so much wood undergoing decay accounts for the growth of the fungi found by the writer in the pure (?) sand of the dune

Fig. 23. High dune at Piermont, Seven-mile Beach, New Jersey encroaching on a forest consisting of *Juniperus virginiana* L., *Ilex opaca* Ait., *Nyssa sylvatica* Marsh., *Quercus lyrata* Walt., *Acer rubrum* L., etc. (see text). Salt marsh beyond.

complex. *Astraeus stellatus* is common. *Thelephora terrestris* is found growing about the stems of *Hudsonia tomentosa*. The puffball, *Lycoperdon Turneri*, was found associated with these, while *Clitocybe trullisata*, found with largely developed base and small pileus, indicates, according to Prof. PECK, who identified it, something unusual in the conditions of growth. *Aethalium septicum*, a myxomycete, is found commonly attached to decaying driftwood.

*Dune Marsh Formation*. The dune-marsh formation is typically developed at Sea Side Park, and to a less extent at Ocean City. The plants which form it inhabit the depressions of the dunes, which reach to water level. The species, therefore, associated together are essentially of a marsh habit. The dune marshes at Sea Side Park are somewhat different in character in different

localities and under varying surroundings. The marshy hollows of the transverse dune complex at Sea Side Park resemble, physiognomically, a typic pine barren swamp in its constituent elements. Such a one, explored, yielded *Juncus effusus*, *Panicum amarum*, *Drosera filiformis*, the cranberry *Vaccinium macrocarpon*, as the character plant of such situations, while near by, as already mentioned, grew other pine-barren forms such as *Sassafras*, *Quercus ilicifolia*, *Q. phellos* etc.

A dune valley, which has not been brought down to the level of the ground water, may consist of pure sand bottom and sides without vegetation, or if plants be present, they are confined to the area of drifted sand and not to the area that is wind-swept. In such a hollow, the drifted sand supports three character plants, viz., *Myrica carolinensis*, *Solidago sempervirens* and *Hudsonia tomentosa*. The sides of the irregular basin, not wind-swept, support the marram grass, and an occasional clump of wax-berry. If the sand is still farther transported by the wind, there remain hillocks of dry sand in the center of a damp stretch on the level of the ground water. Sometimes the bottom of the hollow forms a level trough of wet sand, surrounded by sun-dried sand on all sides. Such a hollow is tenanted by three character plants. The wet sand supports a continuous growth of *Scirpus debilis* and the side of the dune trough, *Panicum virgatum*, a grass which may be called a tussock grass, because it does not form a continuous turf, but grows in clumps more or less isolated from each other. In the higher drier sand of the depression, before the slopes of the dunes of the dune complex are reached, there grows another character plant, *Solidago sempervirens*. We have, therefore, a replacement of the original dune occupants, viz., *Ammophila*, *Hudsonia*, *Myrica*, by three plants, *Scirpus*, *Panicum* and *Solidago*. If this process is carried still farther, then we have a larger number of marsh-loving species appearing in the wet sand of the basin-shaped or elongated depression.

The lower damp, marshy places are covered with a growth of Scirpus debilis, from which arises Typha latifolia and a tall sedge, Scirpus sylvaticus. The higher still damp areas support Cyperus Nuttallii and Juncus sp., although these two plants are, as a rule, not found in association. The islands, or knolls of sand, which remain in the marshy area are held in situ by Myrica carolinensis, Ammophila arenaria and Solidago sempervirens. These three plants grow together side by side. Solidago tenuifolia is found where the sand is damp. The sand marsh is fringed directly with Ammophila arenaria, Solidago sempervirens and an occasional Myrica shrub, while outside of these the slopes of the dunes are windswept and destitute of vegetation. In the degradation of a dune and the formation of a wind-swept hollow, we have a succession of associations which are approaching the ultimate state, that of a mesophytic thicket. The transition, noticed in the dune complex, at Sea Side Park, is from an intensely xerophytic association of species to marsh-dwelling xerophytes, and from these in turn to xerophytic shrubs and trees culminating in a mesophytic thicket filling the extent of the original dune valley.

*Thicket Formation.* The thicket formation developed typically at Sea Side Park and Ocean City reaches its greatest proportions at Wildwood. At South Atlantic City it covers a long, high dune, which is situated, as an island, in the middle of the salt marsh which everywhere surrounds it. It will, therefore,

be described in sequence with the others, although it is misplaced, zonally speaking.

On mile below the town of Sea Side Park the beach thicket covers a considerable area, many acres in extent and quite impenetrable in some places. It is fronted by a strip of juniper trees which are wind-tossed and gnarled by their long struggle with the elements.

Juniper Strip. The vanguard consists of cedars, which never rise above the dunes of the dune complex upon which they grow. Young trees in the dune hollows are spire-shaped, but upon reaching the general level of the dune summit they become flat-topped, incline in the direction opposite to the prevailing wind, and become gnarled and weather-beaten. The cedars of the zone proper form an almost pure growth in front of the main thicket, grow much larger and seem to be more independent of their surroundings. The Juniper Strip clearly defined, is not met with a South Atlantic City, Ocean City or Wildwood, and is apparently absent from those places.

Strip of Mixed Vegetation. This at one mile below the town of Sea Side Park is a veritable jungle, composed of trees, shrubs and lianes, broken there by dry or swampy open glades. The thicket is impenetrable in a number of places owing to the thick growth, and to *Smilax rotundifolia*, covered with spines, and *Ampelopsis quinquefolia*, which together grow as climbing vines, looping themselves from limb to limb and from tree to tree. The most notable species entering into the formation are *Juniperus virginiana* (see fig. 24), *Ilex opaca*, *Iva frutescens* along the margins, *Quercus ilicifolia*, *Rosa carolina*, *Pinus rigida*, *Rhus copallina*, and the climbing form of *Rhus radicans*.

The mesophytic thicket at South Sea Side Park occupies from what bas gone before the hollows or rounded depressions in the dune complex, and in its simplest make-up consists of the following associations of species: One thicket examined consists of Pinus rigida, Sassafras, Vaccinium corymbosum, Juniperus virginiana, Chamaecyparis thyoides (= C. sphaeroidea) and Myrica carolinensis. Another hollow contains Ilex opaca, Juniperus virginiana, Prunus maritima while, as an undergrowth, associated together, are Rhus radicans and Solidago sempervirens. Either before the final condition is reached, or after such thickets have been formed, the original condition of the dune complex may be restored by the drifting in of sand into the depression, resulting in a destruction of the long-established plant associations. Such vicissitudes in the life history of plant associations are not common, althougb examples are found occasionally on the New Jersey strand. As a rule, before the final culmination of dune hollow history is reached, tbe elevated sand hills surrounding it are captured by sand-binding plants, such as Ammophila arenaria, but especially Hudsonia tomentosa, which forms heaths about the depression, effectually preventing the transport of the sand and its deposition in the basin-shaped valleys adjoining.

The thicket at South Atlantic City covers the high insular dune and the hollows and minor dunes behind it. The crest of the dune is probably 30 or 35 feet above the level of the salt marsh, and the hollow behind it is correspondingly depressed. The trees reach a large size, but when they reach the height of the dune summit become flat-topped and wind-swept. The ground of the valley is open, almost entirely destitute of smaller growth, except the smaller trees, and the bracken, *Pteris* (*Pteridium*) *aquilina*.

Wildwood forest, using a dignified term for a remarkable growth of trees and shrubs, is part of the thicket formation on Five-mile Beach, constituted by the association of the following arborescent species: Juniperus virginiana, Prunus maritima, Quercus alba, Q. obtusiloba = minor, Myrica carolinensis, Sassafras officinale, Nyssa sylvatica, Magnolia glauca = virginiana, Acer rubrum (see Fig. 25), Prunus serotina, Quercus falcata and Vitis Labrusca. The vine which grows here reaches a foot in diameter, and is a true liane. Upon the ground, usually in the shady open places, abound Cassia Chamaecrista, Strophostyles helvola, Solidago odora, S. pilosa, Panicum amarum, Eupatorium hyssopifolium, Micania scandens, Lespedeza capitata, Lycopus sinuatus, Lippia lanceolata

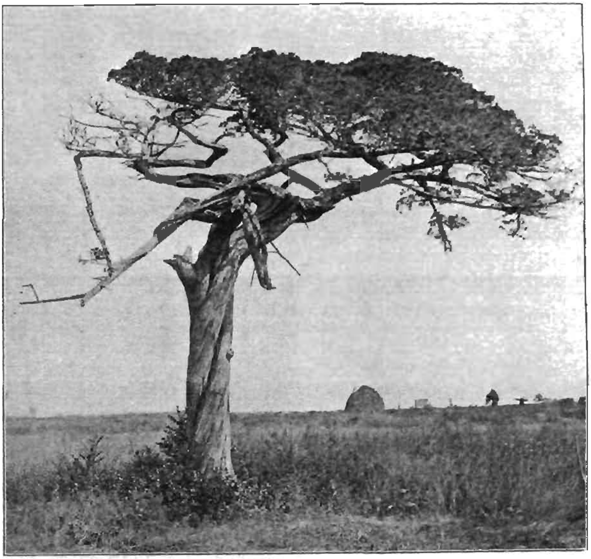

Fig. 24. *Juniperus virginiana* L. (Red Cedar) on Edge of Salt Marsh, Wildwood, New Jersey. Northern Pine-Barren Strand District. Photograph by Geo. D. Firmin.

and *Ambrosia artemisiaefolia*. Within the area of the thicket formation are open spaces representing the depressions of the surface, as well as more elevated sandy glades. Several well-marked associations of plants take possession of these spaces, varying in ecologic composition according to the physiography.

Occurring in the jungle of Wildwood[1]) are a number of well-defined societies classified as follows, with the names of their component character plants:

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1) Forest Leaves, VII, p. 67 and 92. Two articles describing the remarkable tree growth on Five-mile Beach.

Osmunda-Association: Osmunda regalis, Scirpus sp., Impatiens biflora. Lobelia cardinalis.

Discopleura-Association: Discopleura (Ptilimnium) capillacea.

Fig. 25. *Acer rubrum* (Red Maple) in Thicket Formation of Sea Strand at Wildwood, New Jersey. Northern Pine-Barren Strand District. Photograph by Geo. D. Firmin.

Cowbane-Association: Tiedemannia (Oxypolis) rigida, Hibiscus moscheutos.

Polygonum-Association: along the borders of a swampy area grows Polygonum lapathifolium.

*Salt pond- and Salt-marsh Formation.* This formation may be studied to advantage along the northern sea coast of New Jersey, as it is derived from the salt bays, or inlets, that characterize the coast, and it in turn is replaced by the freshwater ponds represented in the region. If an ocean inlet is wholly or partially closed by a barrier of sand that has been formed by ocean currents, or by wind action, a salt pond results. Ultimately such salt ponds are transformed into small fresh-water lakes with a corresponding change in the vegetation, but before that happens, the salinity of the water is maintained, if the pond has a narrow outlet to the sea by the renewal of its water at high tide. If the pond is closed from the sea by a low sand bank, then it is only at exceptionally high tides, or during storms that a new supply of salt water replaces the old which has become essentially brackish. These ponds were studied by the author who has arranged them according to their progress from saline to fresh-water ponds. The transition from a salt water vegetation to a fresh-water can be studied in Sylvan Lake where near the old outlet occur *Spartina patens, Juncus Gerardi, Scirpus pungens, Panicum crus-galli* and *Baccharis halimifolia,* while some distance back from the ocean *Nymphaea odorata* and *Typha latifolia* grow in abundance. The vegetation of the true salt ponds is essentially similar to that of the salt marshes, that of the fresh-water ponds like those of the interior.

The inner strip of the salt marsh is characterized by the presence of *Hibiscus moscheutos.* On the marsh proper occurs in several well-marked zones *Distichlis spicata* in the more elevated portions, while *Salicornia herbacea* and *Bigelovii, Spartina patens* and *polystachya, Limonium carolinianum* grow in the wetter areas with occasional patches of *Scirpus robustus.* Along the edge of the thorofare through which the tidal water circulates is found a pure association of *Spartina stricta maritima.* Near the outer edge of the marsh *Hydrocotyle umbellata* is found, while on exposed sand slopes *Opuntia vulgaris* is at home with a rose and a willow forming nearby thickets.

The salt marshes of New Jersey have been investigated by the author[1] along Newark, Raritan, Sandy Hook Bays, Shrewsbury River, Shark River and Wreck Pond in the north, at South Atlantic City, at Piermont and at Wildwood in the south. The association of salt-marsh species varies in the different localities, but in general it may be said, pending a more detailed statement elsewhere, that Spartina stricta var. maritima, fringes the open salt water of bays, channels and lagoons, back of which grows Spartina patens, if the ground is low, while Distichlis spicata, Juncus Gerardi, Scirpus pungens form extended patches back of the fringe of salt grasses; or if the marsh is narrow and the bank steep back of it, then these plants form strips in pure association. In the autumn these meadows are made bright with Gerardia maritima and species of Sabbatia with showy flowers, while in autumn is found in the marshes at Beesley's Point[1]) in a slight depression

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1) See STONE, WITMER: The coastal Strip of New Jersey and the Rediscovery of Lilaeopsis. Bartonia I: 20—24.

where a fresh-water spring bubbles up the recently rediscovered Lilaeopsis lineata, first collected by THOMAS NUTTALL at this place[1]).

*Bay-beach Formation.* This formation and its ecologic constitution was studied only at Sea Side Park. At exceptionally high tides the whole beach is subject to tidal action, but ordinarily, high-water mark is removed several feet from the limit of vegetation. Along Barnegat Bay large quantities of eel-grass, *Vallisneria spiralis*, is washed ashore. At low-tide mark it is still green, but at high-tide mark it has become dry, hay-like, and of a chocolate-brown color. The supply is derived from the fresh-water rivers which empty into Barnegat Bay. The high beach, out of reach of ordinary tides, supports the following plants: *Amaranthus retroflexus*, *Suaeda linearis* var. *ramosa*, *Chenopodium album*, *Salsola kali*, *Atriplex hastatum*, *Cakile americana*, *Xanthium canadense*, *Erechtites hieracifolia* and *Spartina patens*, which is extremely abundant.

Barnegat Bay and many similar ones along the Jersey coast are practically free from aquatic vegetation, such as *Zostera marina*, *Fucus vesiculosus*, *Vallisneria spiralis*, etc., which may contribute material to fill up the bay with vegetal detritus. The water in physical constitution oscillates between two extremes, salt and fresh. If the barrier between the sea and the lagoon is at times closed, so that the water in the bays become fresh, the result is that plants which are especially adapted to the production of salt marshes are killed by the fresh waters, while the occasional invasion of salt water during storms by way of the dune hollows and stronger tides through the inlets destroys the fresh-water plants, which might otherwise establish a swamp. By these alternations some of the largest bays have been kept open, although in many places shallow in the extreme. *Ruppia maritima*, as it grows in Barnegat Bay, seems to be the only species which has succeeded in adapting itself to such fluctuating conditions. It has been referred to as the character plant of the shallower waters of that bay in about 12—18 inches depth of the sandy bottom, and with the consideration of the above facts its probable future role in preparing the way for other adaptive hydrophytes becomes evident. (Ruppia Shelf.)

### 2. Pine Barren Formation.

The northward extension of the pine barren flora on Long Island and Staten Island has been studied by BRITTON and HARPER[2]). The soil of the region is generally sandy, but is occasionally firm where strata of clay approach and form the surface. The geologic formations to the south and southeast of a line drawn from a point below Long Branch to another near the head of Delaware

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1) Von einer neuen wertvollen Abhandlung von Dr. HARSHBERGER kann hier nur noch der Titel beigefügt werden: The Vegetation of the Salt Marshes and of the Salt and Fresh Water Fonds of northern coastal New Jersey; Proceed. Acad. Nat. Sciences of Philadelphia Aug. 1909 (issued Oct. 1909), 373—400. Hier ist sehr genaue Untersuchung der edaphischen Bedingungen. (Drude.)

2) HARPER, R. M.: The Pine-barrens of Babylon and Islip, Long Island. Torreya VIII: 1—9.

Bay are Tertiary, while those to the north of it are Cretaceous. The Tertiary soils extend southward along the Atlantic to Florida. As the soil over both the Cretaceous and Tertiary is composed of similar materials, it is impossible to say, from surface indications, where one ends and the other begins. On Long Island, the great terminal moraine occupies a position marked by a range of hills extending throughout its whole length at an average distance of ten miles from the Atlantic. South of these hills sandy plains prevail, the material composing them having been formed partly from the modified drift of the hills, partly from the underlying Cretaceous strata.

In Suffolk County these plains are covered with Pinus rigida which is dominant associated with Quercus alba, Q. coccinea, Q. obtusiloba (= Q. minor), and an undergrowth of Q. ilicifolia, Q. prinoides, Andromeda mariana, Gaylussacia resinosa, Rhus copallina, Comptonia asplenifolia, Arctostaphylos uva-ursi and a number of herbs.

Those species detected on the Cretaceous soils of Staten Island in the extreme southern part and not on the drift, are thirty-four in number: Magnolia glauca, Hudsonia ericoides, Ascyrum Crux-Andreae, Arenaria squarrosa, Rubus cuneifolius, Polygala lutea, Tephrosia virginiana, Desmodium laevigatum, D. viridiflorum, Crataegus parvifolia, Eupatorium rotundifolium, Aster nemoralis, Aster concolor, Chrysopsis mariana, Gnaphalium purpureum, Gaylussacia dumosa, Andromeda (Pieris) mariana, Kalmia angustifolia, Ipomoea pandurata, Phlox subulata, Asclepias obtusifolia, Euphorbia ipecacuanhae, Quercus marylandica, (= Q. nigra), Q. prinoides, Q. phellos, Spiranthes simplex, Juncus scirpoides var. macrostemon, Xyris flexuosa, Cyperus cylindricus, Stipa avenacea, Glyceria obtusa, Panicum verrucosum, Andropogon macrourus, Lycopodium inundatum [1]).

Of these herbs, the following have been detected in Suffolk County, Long Island: Pteris aquilina, Tephrosia virginiana, Baptisia tinctoria, Lespedeza hirta, Desmodium viridiflorum, Rubus cuneifolius, Ipomoea pandurata, Gerardia pedicularia, Phlox subulata, Drosera filiformis, Ascyrum stans, Sericocarpus conyzoides, S. linifolius, Eupatorium hyssopifolium, Eupatorium leucolepis, Eupatorium album, Aster spectabilis, A. concolor, Solidago puberula, S. bicolor, Chrysopsis falcata, C. mariana, Helianthus angustifolia, Coreopsis rosea, Utricularia subulata, Chamaecyparis thyoides (= sphaeroidea), Juncus pelocarpus, Xyris caroliniana, Eleocharis melanocarpa, Sporobolus serotinus. Thus it appears that thirty four of these characteristic pine barren plants grow in the southern part of Staten Island, and that a large contingent of them have been detected in Suffolk County, Long Island.

Grass Plain Formation. Prairie-like plains (locally the Hempstead plains), are found in west central Long Island. Here Andropogon scoparius, Chrysopogon avenaceus, Juncus Greenei form the character plants with which are associated Andromeda mariana, Gaylussacia resinosa, Tephrosia virginiana, Lechea villosa, Aletris farinosa, Viola pedata, Polygala cruciata, P. Nuttallii, Bartonia tenella, Solidago puberula, Autennaria neglecta and small isolated trees of Betula populifolia, Populus tremuloides. In general these plains resemble the bunch grass prairies of the prairie region. In the valley of Meadow Brook, which crosses the plains, a swamp and a thicket occur. The ticket shrubs are Rhus vernix, Vaccinium corymbosum, Viburnum dentatum while the swamp plants include Dulichium spathaceum, Polygonum sagittatum, Eriophorum gracile, etc.

These species show a tendency to follow the course of the two more recent geologic formations throughout their whole extent along the Atlantic coast. Another fact, which stands out prominently in this connection, is that not a single one of the above mentioned plants, growing, as we have seen, along the edge of the glacial drift, is native of Europe, but belong to a true

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1) Cf. N. L. Britton, On the northward Extension of the N. J. pine Barrens on Long and Staten Islands. Bulletin Torrey Botan. Club, VII, 81. July 1880.

American flora, which had its origin in the southern part of the continent and migrated northward into Staten Island and Long Island at the close of the great ice age.

In contrast one third of the species on the morainic material is common to northern Europe and America. There are no features on the north side of Long Island that are not duplicated in New York and Connecticut. In the woods the herbs are distinctly northern in their type, hardly extending beyond the ridge. The most important of the pine barren plants which extend north into Long Island and some of them into Martha's Vineyard (see ante p. 380) and Nantucket are here given:

Andropogon glomeratus Walt. (= A. macrourus Michx).
Ascyrum hypericoides L. (= A. crux Andreae L.).
Ascyrum stans Michx.
Aster spectabilis Ait.
» nemoralis Ait.
» concolor L.
Andromeda (Pieris) mariana L.
Drosera filiformis Raf. [Nutt.
Desmodium (Meibomia) laevigatum
» » viridiflorum L.
*Asclepias obtusifolia Michx.
Arenaria caroliniana Walt. (= A. squarrosa Michx.).
*Catharinea crispa* James (= *Atrichum crispum* James).
Crataegus parvifolia Soland. (= C. uniflora Moench).
Chrysopsis mariana L.
» falcata Pursh.
Coreopsis rosea Nutt.
Cyperus cylindricus Ell. (= C. Torreyi Britton).
Eupatorium rotundifolium L.
» album L.
» hyssopifolium L.
» leucolepis T. & G.
Euphorbia ipecacuanhae L.
Eleocharis melanocarpa Torr.
Gnaphalium purpureum L.
Gaylussacia dumosa Andr.
Glyceria (Panicularia) obtusa Muhl.
Hudsonia ericoides L.
Helonias bullata L.
Helianthus angustifolius L.
Ipomoea pandurata L.
Spiranthes (Gyrostachys) simplex
Stipa avenacea L. [Gray.
Sporobolus serotinus Torr.
*Tephrosia (Cracca) virginiana L.
Utricularia subulata L.
Xyris flexuosa Muhl.
» caroliniana Walt.[1])
*Chamaecyparis thyoides L. (= C. sphaeroidea Spach).
*Juncus pelocarpus E. Meyer.
» scirpoides Lam. (= J. scirpoides var. macrostemon Engelm.).
*Kalmia angustifolia L.
Lycopodium inundatum L.
Magnolia glauca L. (= M. virginiana
Polygala lutea L. [L.).
Phlox subulata L.
Panicum verrucosum Muhl.
Quercus marylandica Muench. (= Q. nigra L.).
» prinoides Willd.
» Phellos L.
» heterophylla Michx.
» Rudkinii Britt.
Rubus cuneifolius Pursh.
*Solidago puberula Nutt.

1) Jelliffe, Smith Ely: The Flora of Long Island. Lancaster 1899: XI—XII.

Those plants marked by an asterisk in the above list extend north to Canada. Twenty five of the plants occur on the south shore of Massachusetts about Buzzards Bay near New Bedford[1]), while twenty listed below are found in a limited area about Worden's Pond in southern Rhode Island[2]).

| | |
|---|---|
| Chaemaecyparis thyoides L. | Asclepias obtusifolia Michx. |
| Kalmia angustifolia L. | Aster nemoralis Ait. |
| Gaylussacia dumosa Andr. | » concolor L. |
| Sporobolus serotinus Torr. | » spectabilis Ait. |
| Glyceria (Panicularia) obtusa Muhl. | Solidago puberula Nutt. |
| Xyris flexuosa Muhl. | Eupatorium hyssopifolium L. |
| » caroliniana Walt. | Coreopsis rosea Nutt. |
| Spiranthes (Gyrostachys) simplex A. Gray. | Chrysopsis falcata Pursh. |
| Lachnanthes tinctoria Ell. (= Gyrotheca capitata Walt.). | Tephrosia (Cracca) virginiana L. |
| | Hudsonia ericoides L. |
| | Lycopodium inundatum L. |

The pine barren region of New Jersey may be divided into two portions, *one comprising the* c o n i f e r o u s *area and the other a portion of the transition area,* where the conifers encroach on the d e c i d u o u s v e g e t a t i o n. The coniferous, or pine-barren belt is a strip of land sixty miles long by from eight to twenty miles wide. Its soil varies from a light sandy loam to clean beach sand. Its streams rarely overflow their banks, there are peat bogs, barren plains marl beds, hardwood swamps and cedar swamps which diversify the monotonous landscape. Little diversity in either geology or topography is presented in this territory. The soil has an almost uniform character throughout and the surface irregularities are relatively small. The coniferous vegetation is conterminous with the northern border of the Tertiary gravels, sands and sandy clays, and it is limited on its southern and eastern borders by a fringe of modern sand beaches and salt marshes, while southwestward, it extends beyond the limits of the state, while the tension zone includes practically the whole of the Cretaceous plastic clays and the Cretaceous and Tertiary clay-marls and marls.

The following list according to Witmer Stone (Proceedings Academy Natural Sciences of Philadelphia 1907: 452—459) includes the peculiar pine-barren species and those which occur southward along the Atlantic coastal plain but which find their northern limit in New Jersey:

| | | |
|---|---|---|
| Lycopodium carolinianum. | Carex striata. | Rhynchospora pallida. |
| » alopecuroides. | Cyperus cylindricus. | » knieskernii. |
| Calamofilva brevipilis. | Rhynchospora Torreyana. | Scleria Torreyana. |
| Sporobolus Torreyanus. | » gracilenta. | Juncus marginatus aristulatus. |
| Panicum sphagnicola. | » oligantha. | » asper. |

1) Hervey, E. W.: Flora of New Bedford and the Shores of Buzzard's Bay.

2) Bailey, W. W.: Pine barren Plants in Rhode Island. Bulletin Torrey Botanical Club 1880 VII: 98.

Xyris fimbriata.
Tofieldia racemosa.
Narthecium americanum.
Xerophyllum asphodelioides.
Smilax Walteri.
» tamnifolia.
» laurifolia.
Habenaria cristata.
Lophiola americana.
Lachnanthes tinctoria.
Arenaria caroliniana.

Ascyrum stans.
Hypericum densiflorum.
» virgatum ovalifolium.
Polygala lutea.
» brevifolia.
Desmodium strictum.
Itea virginica.
Leiophyllum buxifolium.
Pyxidanthera barbulata.
Sabbatia lanceolata.

Gentiana porphyrio.
Lobelia Canbyi.
Eupatorium leucolepis.
» resinosum.
Sclerolepis uniflora.
Helianthus angustifolius.
Aster gracilis.
» nemoralis.
Solidago stricta.
» pilosa,
» erecta.

The northern element in the New Jersey pine-barren flora consists of the following species which practically find their south low-ground limits in this region or a little south of it: Schizaea pusilla (recently discovered on the sea strand at Sea Side Park, N. J.), Sporobolus serotinus, Carex livida, C. folliculata, C. trisperma, Eriophorum polystachyum, Juncus pelocarpus, J. militaris, Corema Conradii, Utricularia clandestina, Gaultheria procumbens, Cassandra (Chamaedaphne) calyculata, Arctostaphylos uva-ursi, Vaccinium atrococcum, Chrysopsis falcata. The botanist notices the absence from the pine barrens of such plants as *Symplocarpus (Spathyema) foetidus, *Arisaema triphyllum, Anemone nemorosa, Ranunculus abortivus, R. fascicularis, Thalictrum polygonum, Caltha palustris, Viola cucullata, V. sagittata, *Lobelia cardinalis, Helianthus giganteus, *Vernonia noveboracensis, Senecio aureus. These species are found in the woods of the Delaware Valley and uplands beyond and those marked near the seacoast.

*Forest Formation.* The pine barrens consist of unbroken extents of dark green pine forest never rising over fifty feet above ground level. *Pinus rigida* is the most abundant tree and forms according to my observations an open forest with an undergrowth of oaks and ericaceous plants. (Pinus rigida — Facies.) The second layer comprises such trees as *Quercus marylandica*, *Q. obtusiloba* (= *Q. minor*, *Q. stellata*), *Q. alba* (rare) and the third layer consists of many shrubs and small trees sometimes in dense masses at other places in widely open formation and varying in composition according to the locality and edaphic conditions.

These are: Quercus ilicifolia (=Q. nana), Q. prinoides, Crataegus parviflora, Vaccinium pennsylvanicum, corymbosum, vacillans, Gaylussacia dumosa, resinosa, frondosa, Andromeda ligustrina, Azalea viscosa, Leucothoe racemosa; Kalmia latifolia, K. angustifolia, Viburnum nudum and Comptonia, Leiophyllum buxifolium, while of prostrate habit are Mitchella repens and Arctostaphylus Uva-ursi (in masses several yards in extent), together with such herbs as Xerophyllum asphodelioides, Pteris aquilina, Chimaphila maculata, C. umbellata (both in large patches, while in such an association of species in different places in the forest we find also Lupinus perennis, Hieracium venosum, Euphorbia ipecacuanhae, Diplopappus Iineariifolius, Chrysopsis mariana, C. falcata, Liatris spicata, L. graminifolia, Aquilegia canadensis, Arenaria caroliniana. In more open sandy places with a gentle slope grow Pyxidanthera barbulata, Epigaea repens, Gaultheria procumbens, Breweria Pickeringii, Croton capitatus, while Hudsonia ericoides cover hillocks of sand together with Galactia glabella, Cladonia rangiferina, Phlox subulata, Opuntia vulgaris, Helianthemum canadense, Crotonopsis linearis, Euphorbia ipecacuanhae and Lechea minor. In dry woods occur Rubus cuneifolius, R. hispidus, Baptisia tinctoria, also Monarda punctata, Asclepias tuberosa, Amianthium muscaetoxicum, Tephrosia virginiana, Cypripedium acaule, Corallorhiza multiflora, Melampyrum lineare, Viola pedata. Pinus inops (= P. virginiana) is abundant along the Delaware River on gravelly ridges. Small clumps and single trees are scattered through the southern interior. Pinus mitis (= P. echinata) grows on sandy or light clayey soil. It is quite common in the

marl belt of the state but it also frequently crosses the line and becomes an element of the pine barren forest. Finally Pinus taeda reaches Cape May County New Jersey in a few individuals associated with Quercus alba, Q. ilicifolia, Q falcata, Q. phellos, Q. rubra and scattered trees of Pinus inops and P. rigida and a typic pine barren undergrowth[1].

Quercus Association. The oaks form an association called locally oak barrens. Here *Quercus alba*, *Q. obtusiloba*, *Q. marylandica*, *Q. Prinus*, *Q. coccinea*, *Q. ilicifolia* are prominent and they sometimes encroach on the pine forest, and when the pine is cut down it is replaced by an oak thicket. Originally the oaks rapidly diminished in numbers toward the center of the pine barrens. As an element of this association especially along streams in dry ground are found *Liquidambar styraciflua*, *Sassafras*, *Clethra*, *Ilex opaca*, *Amelanchier*, *Juniperus virginiana*, *Rhododendron nudiflorum*. On the *Nyssa* trees settles *Phoradendron flavescens*, while as lianes are *Smilax rotundifolia*, *Ampelopsis*, *Clematis virginiana*, *Celastrus scandens*.

Open stretches of country known locally as the plains consist of a rolling sand surface covered by dwarf trees of *Pinus rigida*, *Quercus ilicifolia*, *Q. marylandica*, scarcely over two or three feet high. Here the laurel, *Kalmia latifolia*, luxuriates associated with *Corema Conradii*, *Arctostaphylos uva-ursi* and *Epigaea repens*.

## 3. Swamp-, Bog- and Pond-Formations.

*Cedar Swamp Formation.* This formation is characterized by the white cedar *Chamaecyparis thyoides* (= *sphaeroidea*). It grows in dense masses along fresh water streams. Associated with this tree are *Magnolia glauca*, *Acer rubrum*, *Azalea viscosa*, *Itea virginica*, *Ilex verticillata*, *I. glabra*, *Clethra alnifolia*, *Gaylussacia frondosa*. *Usnea barbata* hangs from the trees and other lichens cover the stems and branches, while sphagnum forms cushions at the base of the trees. In sandy open places of small extent or about the bases of the cedar trees in sphagnum, notably at Island Heights Junction, at Forked River at Chatsworth and Quaker Bridge is found the rare and local *Schizaea pusilla*, associated with *Lycopodium carolinianum* and *Drosera rotundifolia*, *intermedia* and *filiformis*. In such swamps also grow *Orontium aquaticum*, *Eriocaulon*, *Osmunda cinnamomea*, *O. regalis* and *Sarracenia purpurea*.

The cedar swamps in Long Island according to HARPER and BICKNELL (Torreya VII: 198, VIII: 27) occur in a few localities along the south shore of the island. Here are associated with the white cedar Sassafras officinale (a foot in diameter), Acer rubrum and the following shrubs and herbs: Viburnum dentatum, Kalmia latifolia, Clethra alnifolia, Aralia nudicaulis, Ampelopsis quinquefolia, Nemopanthes fascicularis, Rhus radicans, Rubus hispidus, Maianthemum canadense, Arisaema triphyllum, Symplocarpus foetidus, Carex folliculata, Lycopodium lucidulum, Osmunda regalis, O. cinnamomea, Woodwardia areolata, Trientalis americana, Azalea viscosa and Gaylussacia frondosa.

Hardwood Swamp Formation. The hardwood swamps along streams, or interspersed in low places through the pine barrens usually contain Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Magnolia glauca, Rhus venenata, Clethra alnifolia, Vaccinium corymbosum, Ilex verticillata,

1) HOLLICK, ARTHUR: The old field Pine in New Jersey. Plant World I. 24. Nov. 1897.

Itea virginica, Alnus serrulata. In Griscom's swamp between Tuckahoe and Great Egg Harbor rivers occur Fagus americana, Liriodendron tulipifera, Quercus bicolor, Q. pbellos, Q. alba, Q. prinus, Ilex opaca, Sassafras, Nyssa, Pinus rigida and Magnolia. It is remarkable that in this swamp one finds Quercus bicolor the only place where it grows in South Jersey and also Fagus and Liriodendron separated from the broad leaved forest by a broad stretch of pine land. Similar swamps, according to Harper, occur in Long Island.

*Grass Slough Formation.* There are many acres of grassgrown land in New Jersey, which approach the "savanna". This so called savanna consists of sloughs covered with a variety of grasses associated with *Hibiscus moscheutos, Decadon verticillata, Tofieldia, Narthecium,* while knolls or ridges are covered by *Pinus rigida* with *Xerophyllum asphodeloides.* The sloughs are underlaid near the surface by a layer of bog-iron ore and are fringed by boreal plant: *Lyonia (Chamaedaphne) calyculata* with *Vaccinium corymbosum.* — There are in these territories also cranberry bogs, forming a Cranberry Bog Formation proper; the basis of these bogs is sphagnum moss of several species, and they may occupy depressions of surface, or they may fringe the banks of some fresh water stream. The bog is too wet for trees to grow, but we find characteristic species in it, such as *Vaccinium macrocarpon,* which forms dense tangles of growth on its surface, *Sarracenia, Lachnanthes tinctoria, Lophiola aurea, Pogonia* (2 spec.), *Calopogon, Arethusa, Drosera* (3 spec.), *Utricularia clandestina,* and near the margins of the bog *Helonias bullata.*

*Pond Formation.* This includes both floating amphibious and pond margin plants. — (Nymphaea Association): The water surface of the pond is covered either in whole or part by *Nymphaea (Castalia) odorata, Nelumbo lutea* (rare), *Nuphar (Nymphaea) advena, Brasenia peltata (= B. purpurea), Limnanthemum lacunosum* and *Orontium aquaticum.* In the water inside of the floating aquatics is found the Typha-Sagittaria Association, together with *Peltandra virginica* in the shallower water and *Pontederia cordata, Eriocaulon, Scirpus subterminalis* and two or three species of *Xyris,* floating species of *Utricularia*: in thick tangled masses.

The vegetation of Watering Place Pond, according to Saunders[1], is characterized by Nymphaea odorata and several floating islands of sphagnum supporting Lyonia calyculata and in the shallowest water Carex Walteriana, Woodwardia virginica, while in the sphagnum-lined margin (circumarea) grow Pogonia ophioglossoides, Calopogon pulchellus, Drosera filiformis, D. intermedia, Polygala Nuttallii, P. lutea, Lysimachia stricta, Proserpinaca pectinata, Hypoxis erecta and the shrubs Azalea viscosa, Vaccinium corymbosum.

Mention should be made of the grasses of the following genera which abound in the pine barrens: Andropogon, Uniola, Triodia (Triplasis), Stipa, Panicum, Glyceria, Cenchrus and the following characteristic species not mentioned before: Habenaria cristata, H. ciliaris, Calopogon pulchellus, Tephrosia virginiana, Lespedeza hirta, L. repens, L. angustifolia, Polygala cruciata, P. brevifolia, P. incarnata, P. mariana, P. Nuttallii, P. polygama, Ascyrum stans, Oenothera sinuata, Bartonia tenella, Sclerolepis verticillata covering old ditch bottoms, Eupatorium rotundifolium, E. album, E. hyssopifolium, Solidago puberula.

1) SAUNDERS, C. J.: The Pine Barrens of New Jersey. Proceedings Academy of Natural Sciences of Philadelphia 1900: 544—549.

## B. Carolinian Pine Barren-Strand District.

This district includes the coastal plain east of the "fall line" between Chesapeake Bay and south central Florida. Its physical characters are similar to those of the plain in New Jersey, but more pronounced, because in the south the plain is wider and better developed. Floristically the district is richer than that north of the Chesapeake and there are many plants, such as *Uniola paniculata*, *Borrichia frutescens* (peculiar to it) to be mentioned sub-sequently which do not extend northward.

The Lafayette and Columbia geologic formations cover almost the entire surface of the coastal plain in Georgia. R. M. HARPER in a detailed account of this region distinguishes in addition to the Lafayette and Columbia formations the fall-line sand hills, the Altamaha Grit region and the southern lime-sink region, while the Cretaceous, eocene and oligocene geologic regions are also noteworthy. These formations may be identified by the plants growing upon them. Certain species of herbaceous plants occur only on the Columbia sands others only on the Lafayette clays[1]). The best indicator of the Columbia formation is *Eriogonum tomentosum* which flowers in late summer ranging from South Carolina to Florida and Alabama. *Froelichia floridana* has a similar distribution.

Baldwinia angustifolium, Asclepias humistrata, Baptisia perfoliata, Chrysobalanus oblongifolius, Calamintha coccinea, Croton argyranthemum, Dicerandra linearifolia, D. odoratissima, Petalostemon corymbosum, Nolina georgiana, Paronychia herniarioides, Sarracenia flava, Serenoa serrulata are also characteristic. — The Lafayette formation is easily distinguished by Berlandiera tomentosa, Crataegus aestivalis, Dichromena latifolia. There are, however, quite a number of species in the coastal plain which seems never to occur where the Lafayette is present, but only on the Columbia or on outcrops of the older underlying strata. Among these are Bumelia lanuginosa, Dichromena leucocephala, Erythrina herbacea, Hydrangea quercifolia, Melanthera hastata. Taxodium distichum and Yeatesia (Justicia) laetevirens. Lastly Tiedemannia teretifolia and Taxodium imbricarium seem to indicate the simultaneous occurrence of both the Lafayette and the Columbia geologic formations.

### 1. Sea Coast- and Dune Formations.

*Marine Algal Formation.* The nature of the bottom of the ocean and sounds along the southern coast of the United States is such as to provide few habitats of the sort most frequented by marine algae. There are no rocks whatever, except those artificially deposited for wharves and revetments. Rock pebbles are also wanting. It is not surprising, therefore, to find that the marine algae are such forms which attach themselves to shells lying on the

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1) The most detailed account of the physiography and soils of the coastal plain with the best agricultural map ever published of the district will be found in a report by EUGENE A. HILGARD entitled, "Report on cotton Production in the United States also embracing agricultural and physiographical Descriptions of the several cotton States". Tenth Census of the United States, volumes V and VI, 1884. This is indispensable in a study of the flora of the Southern states in connection with the chapters in Hilgard's book on "Soils" concerned with the recognition of soils from their native vegetation, pages 487—549; Consult also MILTON WHITNEY, Soils of the United States. Bulletin 55 U. S. Bureau of Soils, 1909 with excellent colored map.

sandy or muddy bottom. Probably the most common marine plant of the sounds, except perhaps *Ulva lactuca*, is *Hypnea musciformis*, which grows in thick masses in every available situation. Scattered quite generally with this plant are tufts of *Dictyota dichotoma* here near its northern limit, associated with *Rhabdonia tenera* and *Gracillaria confervoides*[1]). *Codium tomentosum* frequently occurs on shells in the sounds but more abundantly on the rocky breakwaters associated here with *Dictyota*, *Padina pavonia*, *Sargassum vulgare*, upon which is found as an epiphyte *Ectocarpus siliculosus*, while on exposed breakwater rocks are found *Enteromorpha* and many delicate Rhodophyceae, chief among which are *Dasya elegans*, *Erythrotrichia*, *Gelidium*, *Grinnellia americana*, *Trentepohlia virgatula* with several species of *Callithamnion*, *Ceramium* and *Polysiphonia*. *Zostera marina* is abundant in the sounds and on its leaves flourishes *Melobesia pustulata*. — Paralleling and fringing these sounds and inlets are the salt marshes of the coast many of them very extensive in area. According to KEARNEY[2]) the following formations may be distinguished in southeastern Virginia and North Carolina.

*Salt Marsh Formation*. Salt marshes exist as a conspicuous element in the topography of the region bordering tidal streams and sounds up to the point where the water ceases to be brackish, but not infrequently, they cover wider areas in lagoons and bayous. At the meeting place of the salt and freshwater marsh vegetation, the plants of the tension line are *Spartina polystachya* and *Scirpus americanus* (salt water plants), associated with *Sagittaria lancifolia*, *Pontederia cordata*, *Polygonum hydropiperoides*, *Typha latifolia*, *Zizania aquatica* (freshwater marsh species).

Several associations of species may be distinguished in the salt marsh: Spartina stricta Association. This association in which *S. stricta* var. *maritima* is the most important species occupies the edge of the open water, associated with it as secondary species are *Salicornia*, *Distichlis spicata*. Where these plants grow the tidal range is marked, so that the plants are partially submerged at high tide.

Juncus Roemerianus Association. This association occupies more ground than the former and is best developed on land that is merely wet a great part of the time and covered at most with only a few centimeters of water at high tide. *Juncus Roemerianus* is perhaps the most abundant salt marsh plant of the region growing inside *Spartina* and affording a striking contrast to that plant by its dark green almost black color. In Virginia besides *Juncus Roemerianus* among the most abundant plants is the shrubby *Iva frutescens* associated with *Aster subulatus*, *Lythrum lineare*, *Statice caroliniana*, while atone point below Virginia Beach an assemblage of species

1) JOHNSON, DUNCAN S.: Notes on the Flora of the Banks and Sounds at BEAUFORT, N. C. Botanical Gazette XXX: 405—410. Dec. 1900.

2) KEARNEY, THOMAS H.: The plant Covering of Ocracoke Island. Contributions U. S. National Herbarium 1900 V: 261—319; Report on a botanical Survey of the Dismal Swamp Region do. 1901 V: 321—585.

occupies the pools among the rushes — *Herpestis monniera*, *Eleocharis mutata* and *glaucescens*, *Paspalum distichum*.

Typha Association. This association covers rather wide strips in nearly pure association especially near the upper limit of brackish water along streams in Virginia. — Spartina juncea Association. This forms dense meadow-like areas on the salt marshes in Virginia, and breaks the usually uninterrupted stretches of the Juncus Roemerianus Association. *Spartina patens* (= *S. juncea*) is the chief species associated in midsummer with *Sabbatia stellaris*, *Fimbristylis spadicea* and clumps of the grass *Panicum virgatum*. — Baccharis-Hibiscus-Association. A number of species are mostly at home in the wet soil at the inner edge of the salt marshes whence they stray into the other associations. Most important of these is *Baccharis halimifolia*, *Hibiscus moscheutos*, *Borrichia frutescens*, only occasional in Virginia, although common farther south along the coast. *Panicum virgatum* in clumps is also a conspicuous feature of marsh borders as also *Kosteletzkya virginica*, *Mikania* (*Willugbaea*) *scandens*, *Rumex verticillatus*, *Pluchea camphorata*, *Atriplex hastatum*.

The lack of space enables us only to mention the Dune Marsh Formation which cover limited areas of wet sand in depressions among the dunes on Ocracoke Island, N. C. with the most characteristic species of Herpestis monniera, Lippia nodiflora, associated with Hydrocotyle umbellata, Centella asiatica, Diodia virginiana; then the Tidal Flat Formation, an open formation occupying the margins of shallow lagoons at the end of Ocracoke Island, North Carolina, with the soil as a mixture of silt and sand and an association of a sparse growth of Sesuvium pentandrum, Spergularia (Tissa) marina and Scirpus pungens, followed by the Strand Formation of Virginia, North Carolina, Georgia and Florida, where as in other parts of the world, the well marked topographic feature, the sand strand, is occupied by a sparse vegetation, in open formation, i. e., where the individual plants mostly grow far enough apart to leave much of the soil visible among them.

*Beach Formation*. In the Dismal Swamp region in Virginia at Virginia Beach, according to my observations and those of KEARNEY[1]), the lower and middle beaches are almost destitute of plants except *Zostera marina* which has been thrown up by the waves. The upper beach, however, is characterized by a growth of *Cakile americana*, *Salsola Kali*, *Arenaria peploides* and a scattered growth of *Ammophila arenaria*.

The plant associations of the sand strand of Lynnhaven Bay are less exposed to the wind than the shores of the Chesapeake and the open Atlantic and they are therefore somewhat different. The narrow strip of beach is in front of an abrupt bank upon the top of which is found the edge of the inland forest. The outer beach supports a growth of Ammophila arenaria, Panicum amarum, Salsola Kali, Cakile americana, Hudsonia tomentosa, Lechea maritima, Spartina juncea, Cenchrus tribuloides var. macrocephalus. Several leguminous plants also occupy the beach: Strophostyles helvola, Centrosema virginiana.

Along Pamlico Sound in North Carolina, according to KEARNEY[2]) the gently sloping sandy

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1) KEARNEY, THOMAS H.: Report on a botanical Survey of the Dismal Swamp Region. Contributions U. S. National Herbarium V: 1901, 368.

2) KEARNEY, THOMAS H.: The plant Covering of Ocracoke Island. Contributions U. S. National Herbarium 1900 V: 270.

beach is occupied by herbaceous plants, named the Croton-Physalis Association. The most abundant is Croton maritimus which forms at places close associations Physalis viscosa, a perennial herb, is also frequent, while Ilex vomitoria (= I. cassine), Zanthoxylum, Juniperus virginiana, Opuntia pes-corvi form diminutive thickets only 1—3 decimeters high. The well known Euphorbia polygonifolia, Triodia purpurea, Solanum nigrum (a canescent form), Salsola kali, Teucrium Nashii, Chloris petraea, Panicum neuranthum, Cynodon dactylon. Rubus trivialis and Smilax bona-nox form the herbaceous element of the beaches.

*Dune Formation.* A visit to the dunes of Virginia Beach by the writer confirmed in all essential details the observations of KEARNEY. The outer line of dunes is inhabited by certain hardy, strong-rooting plants, viz., *Ammophila arenaria*, with small colonies of *Uniola paniculata*, which entirely replaces *Ammophila* not far south of this region. *Iva imbricata* forms roundish clumps on the outermost dunes. *Panicum amarum* is associated with the above plants.

Myrica Strip. This association is found on the middle open dunes (dune complex). Here *Cakile americana* and *Salsola Kali* occur, but are not characteristic. *Uniola* and *Iva* are absent, while on the other hand *Ammophila* and *Panicum amarum* are quite at home. *Ammophila* at times forms meadows like growths associated with scattered dwarf plants of *Myrica carolinensis*, *Quercus virginiana* var. *maritima*, *Rhus copallina*, but *Myrica* forms dense thickets on the higher dunes to the exclusion of other shrubby species.

Other shrubs, however, occur on the open dunes such as Prunus angustifolia, Salix fluviatilis, Quercus virginiana (= Q. virens), Baccharis halimifolia, Cephalanthus occidentalis, Platanus occidentalis. The live oak Quercus virginiana (= Q. virens) hardly occurs as a tree on the Virginia coast nor does it form thickets. Among the open dunes it is a straggling shrub usually wind swept. While the open dunes are not forested, scattered trees often grow upon them. Pinus taeda usually advances farthest toward the beach while Prunus serotina, Diospyros virginiana, Quercus falcata, Ilex opaca also occur. — Climbing plants according to my observations abound in the middle dunes. Tecoma radicans, Vitis rotundifolia, V. aestivalis, Smilax bona-nox, S. rotundifolia, S. glauca, Lonicera sempervirens, Rhus radicans, Amelopsis quinquefolia as lianes. — Beneath and among these occur on the sand Hudsonia tomentosa, Lechea maritima, Diodia teres, Rubus villosus. In the shelter of the bushes ot Myrica carolinensis, not especially adapted to the dune environment, are Erigeron canadensis, Eupatorium capillifolium, Phytolacca decandra, Chenopodium anthelminticum.

The open dunes of Ocracoke Island, North Carolina are occupied by sea oats, *Uniola paniculata*, associated with *Muhlenbergia filipes*, rather small plants of *Yucca gloriosa*, an occasional *Yucca aloifolia*, and *Myrica carolinensis* (Uniola-Yucca Association). Of secondary importance, *Panicum amarum*, *Spartina patens*, *Carduus spinosissimus*, *Oenothera humifusa*, *Croton maritimus* are found.

The tops of the low outer dunes on the Isle of Palms, South Carolina, according to COKER, are held by several sand-binding grasses, each of which seems to dominate particular elevations. Uniola paniculata, which is most abundant, covers many of the ridges, Sporobolus virginicus has possession of others, and Panicum amarum and Spartina polystachya occur in considerable quantity. Here grow also Croton maritimus, Iva imbricata, Salsola kali, Euphorbia polygonifolia, Oenothera humifusa and Cenchrus tribuloides. At certain places the tide makes in between the outer ridges and floods the depressions behind them. Here Coker found Ipomoea

littoralis its northern limit. In the somewhat sheltered depressions among the dunes there are also a few scattered specimens of Yucca gloriosa and near the inner ridges Sabal palmetto grows together with Yucca aloifolia, Uniola paniculata, Quercus virginiana (= Q. virens, in low contorted thickets) over which twines Gelsemium sempervirens. The sand on the steep leeward slopes of the highest dunes is anchored by such vines as Cissus bipinnata (= Ampelopsis arborea) Ampelopsis quinquefolia, Rhus radicans, Vitis rotundifolia, Passiflora incarnata, Smilax bona-nox. Occasionally Quercus virginiana, Persea carolinensis, Morus rubra, Callicarpa americana, Myrica carolinensis and Ilex Cassine (= vomitoria) grow here.

The dunes in Florida, at Daytona for example, consist of two parallel ridges, according to WEBBER[1]. Uniola paniculata is the main sand-binding grass to be found on the top and seaward side of the first line of dunes. Species of Spartina, Panicum, Ipomoea, Yucca, Serenoa, Croton, Euphorbia, Opuntia are also commonly found mingled with Uniola. At the base of the main line of dunes are Panicum amarum, Ipomoea pes-caprae, Ipomoea littoralis, Iva imbricata, Cakile americana. On the dunes at Pablo Beach, Quercus virginiana and Q. aquatica (= nigra) are shrubs associated with the saw palmetto Serenoa serrulata, and such herbs as Physalis viscosa, Croton maritimus (= C. punctatus), Helianthemum arenicola, Oenothera humifusa, Houstonia rotundifolia, Acanthospermum xanthoides, Eclipta erecta, Samolus floribundus, Herpestis monniera, Lippia nodiflora.

The Shell Islands are situated on the east coast flora of Florida, scattered through the marshes and composed entirely of oyster shells[2]. Yucca aloifolia is a dominant plant on some of these islands associated with shrubby growths of Sageretia Michauxii, Forestiera porulosa, Quercus virginiana while climbing over these is Vincetoxicum sp. and beneath a growth of Capsicum frutescens. Possum Island, another shell island, is covered with Opuntia pes-corvi, O. vulgaris, Yucca gloriosa, Mentzelia floridana.

## 2. Coast Forest Formations.

*Dune Forest Formation.* The higher, inner, wooded dunes at Virginia Beach bear, according to my observations, an open forest of *Pinus taeda* and the following according to KEARNEY mingle with or take the place of the pine: *Prunus serotina*, *Diospyros virginiana*, *Zanthoxylum*, *Sassafras*, *Juniperus virginiana* and at Cape Henry occur thickets of laurel oak *Quercus laurifolia*. *Quercus virginiana* (= *Q. virens*) attains its best development beneath the pines in Virginia although it never becomes a tree in this region.

Strand Pine Association. The principal tree of this facies in the Dismal Swamp Region is *Pinus taeda*; associated with the pine and giving character to the association are: *Callicarpa spinosa*, *C. americana*, *Zanthoxylum*, *Gelsemium sempervirens*, *Tecoma radicans* and other lianes are abundant. Where the strand forest is moist, *Baccharis halimifolia* is often the principal element of the undergrowth. In very dry soil, in openings among the trees are *Rubus cuneifolius*, *Robinia pseudacacia*, *Prunus angustifolia*. The herbaceous species of this association are such as typify the drierparts of the inland pine-barrens: *Danthonia sericea*, *Uniola gracilis* (= *U. laxa*), *Convolvulus americanus*, *Eupatorium* many species, etc. In somewhat boggy soil occur *Galium*

1) WEBBER, HERBERT J.: Notes on the strand Flora of Florida. Science new ser. VIII: 658, Nov. 11, 1898; LEEDS, B. F.: Winter Vegetation on Florida sand Dunes. Garden and Forest V: 21 Jan. 12, 1892.

2) CURTISS, A. H.: A Visit to the shell Islands of Florida. Botanical Gazette IV: 117, 132, 154.

*claytonia*, *Panicum ciliatum*, *Polytrichum commune* and small quantities of peat mosses.

The summit of the bluff along Lynn Haven in the Dismal Swamp neighborhood is occupied by the edge of the island forest. The prevailing pine is Pinus mitis (= P. echinata). At other points Pinus taeda predominates. Other characteristic trees are Quercus obtusiloba, Q. falcata, Diospyros virginiana, and Carya porcina (= Hicoria glabra), Myrica carolinensis, Rhus copallina, Symplocos tinctoria, Persea pubescens, Quercus falcata form in places thickets at the foot of the bank. Tillandsia usneoides drapes the trees. Of lianes there are Smilax bona-nox, Tecoma radicans, Rhus radicans. In the open pine woods at the foot of this bank are swards of Festuca rubra, clumps of Panicum virgatum and numbers of Yucca filamentosa, Opuntia vulgaris. In the more elevated pine woods occurs a scanty herbaceous flora of Tragia urens, Jatropha stimulosa, Desmodium strictum, Sporobolus asper, Chrysopsis graminifolia, Galium hispidulum, Uniola longifolia, Helianthemum canadense, Rubus trivialis.

Quercus virginiana Association. Scattered over Ocracoke Island, KEARNEY states there are small groves of *Quercus virginiana* (= *Q. virens*) either in pure association or mixed with other trees. The branches gnarled and twisted are clad with *Usnea barbata* and small wisps of *Tillandsia usneoides*. Associated with the oaks are small trees of *Myrica cerifera*, *Zanthoxylum*, *Ilex*, *Juniperus* and lianas.

The herbaceous members of this association are in the smaller groves: Chloris petraea, Physalis viscosa, Diodia teres and in the larger groves where the light is more diffused and humus collects Oplismenus setarius, Asplenium ebeneum, Uniola gracilis, Panicum laxiflorum and two mosses on the ground Bryum argenteum, Rhynchostegium serrulatum.

Ilex Cassine Association. Thickets of *Ilex vomitoria* (= *I. Cassine*) on Ocracoke Island cover the low dunes of the inner side of the island. The branches of this shrub are shaggy with *Ramalina montagnei*. Associates of the *Ilex* are *Myrica carolinensis*, *Parietaria debilis*, and *Melothria pendula* with twining stems. Inside of the dune formation on Bogue Bank near Beaufort, N. C. the strand forest formation consists of a scrubby forest made up chiefly of *Quercus virginiana* (= *Q. virens*), *Ilex opaca*, *Morus rubra*, *Persea carolinensis*, *Carpinus caroliniana*, *Juniperus virginiana* and *Pinus taeda*. The shrubby undergrowth consists of *Myrica gale*, *Ilex glabra*, *I. cassine*.

The distribution of species here is dependent largely upon the level of the surface. Pinus, Juniperus, Morus occur chiefly in elevated places while Ilex opaca, Carpinus and Persea with the three species of Quercus occupy the hollows and these trees are everywhere overgrown with dense tangles of Berchemia volubilis, Vitis rotundifolia, Rhus toxicodendron, Ampelopsis quinquefolia, Smilax bona-nox, S. rotundifolia, Cissus stans, Melothria pendula. Where the growth is densest epiphytes occur. Polypodium incanum, forms straggling clumps, usually on the live oak, species of Frullania, Liochlaena, Lejeunia and Archilejeunia form reddish or yellowish patches on the trunks of the trees with lichens of the genera Parmelia, Ramalina, Placodium, Buellia, Lecidea and Usnea barbata with a bright red lichen Trypthelium cruentum.

*Palmetto Formation*. *Sabal Adansonii* (= *S. glabra*), present on these banks borders pools of muddy water beneath which are dense patches of *Saururus cernuus* (Saururus Association), *Sagittaria lancifolia* together with *Nephrodium thelypteris*, *Onoclea sensibilis*, *Osmunda regalis* (Sagittaria Association).

**Sabal (Inodes) Palmetto** (Walt.) R. & S. (cabbage palm)
on Smith's Island, mouth of Cape Fear River, North Carolina. Palmetto Formation, Carolinian Pine Barren — Strand District, Young palmettos are shown in the right hand foreground.
Reproduced by permission U. S. Forest Service.

On Smith's Island, a delta-like formation at the mouth of the Cape Fear River, North Carolina, Sabal Palmetto (= *Inodes palmetto*) reaches its northern limit[1] (see plate IX).

Associated with it in a forest of considerable denseness and impenetrability are: Ilex (= I. cassine), Ilex opaca, Quercus virginiana, Q. aquatica (= nigra), Juniperus virginiana, Osmanthus americana, Pinus Taeda. Sabal palmetto makes a magnificent growth in soil consisting of pure sand and shell fragments and on the Isle of Pines, South Carolina, according to Coker, it is associated in the hammocks with Quercus virginiana, Q. laurifolia, Juniperus virginiana and such shrubs as Zanthoxylum clavaherculis, Ilex vomitoria, Bumelia tenax, Callicarpa americana, Yucca filamentosa, Opuntia vulgaris, O. pes-corvi and the herbs Stenotaphrum americanum, Cynodon dactylon, Sporobolus indicus, Panicum lanuginosum, Sanicula canadensis, Galium hispidulum, Monarda punctata, Bidens frondosa and Eupatorium leucolepis. Smilax laurifolia festoons the trees and Mitchella repens forms carpet on the ground in the shade beneath. Sabal Adansonii which ranges farther south is absent from this island.

*Oak Flats Formation.* In this connection must be mentioned the oak flats which border most of the gum and cypress swamps, lying between the swamps (see later) and the level pine land. The soils of these flats are damp or moist usually deep loams covered with broad-leaved trees, viz., *Quercus aquatica* (= *Q. nigra*), and other oaks, species of *Ulmus*, *Acer*, *Liquidambar*, *Nyssa*. These form an upper story 80 to 100 feet in height and of considerable density while beneath them are *Carpinus caroliniana*, *Quercus obtusiloba*. There is little undergrowth. Where the soil of the oak flats becomes peaty, *Liriodendron tulipifera* occurs occasionally among the other trees.

### 3. Inland Forest Formations.

The forests of the interior of the Carolinian coastal plain are of three types constituting three groups of phytogeographic formations: Mixed Forest Formations, Pine Barren Formations, Hygrophile Forest Formations, the latter including the forest of the black gum swamp (cypress swamp) and that of the open light swamp. These formations have been most carefully studied in southeastern Virginia and northeastern North Carolina and we owe our knowledge to the energetic field labors of THOMAS H. KEARNEY. Less is known of similar portions south of North Carolina and in the absence of more detailed information the character of the Virginia and North Carolina areas must be considered as typic and in all probability the difference is not in the physiognomy of the vegetation north and south, but in the presence or absence of certain north or south ranging plants.

*Mixed Forest Formations.* The forest which still covers large areas of the coastal plain is usually a mixture of coniferous and deciduous trees. Where the conditions have not been disturbed, the loblolly, or rosemary pine (*Pinus taeda*) is still the dominant species in sandy soils. On stiffer soils, especially away from the sea, hardwoods of several species constitute the

1) MASSEY, W. F.: The northern Limit of Sabal Palmetto. Garden and Forest V: 189. April 20, 1892.

strongly predominant or even in small areas, sole element of the forest growth. *Pinus mitis* (= *P. echinata*), is not rare and *Pinus palustris* (= *P. australis*) occur sparingly in the formation. The most important deciduous tree is *Liquidambar styraciflua* with *Quercus alba*, *Q. Michauxii*, *Q. falcata* (*Q. obtusiloba*), *Q. phellos*, less common are *Q. rubra*, *Q. tinctoria*, *Q. laurifolia*. The beach most abounds where the subsoil is particularly rich in clay or silt and therefore retentive of moisture. *Acer rubrum* (fig. 25 page 418) is common generally in swamps. *Carya tomentosa* (= *Hicoria alba*), *Liriodendron* are less abundant than the preceding. *Cornus florida*, *Oxydendrum arboreum*, *Ilex opaca*, *Diospyros virginiana*, *Nyssa sylvatica* are abundant.

Other elements of forest growth are in places Celtis occidentalis, Carya porcina (= Hicoria glabra), Juglans nigra, Juniperus virginiana, Morus rubra, Ulmus americana, Castanea pumila, Persea pubescens, Sassafras officinale, Prunus serotina. All of these species, but especially Liquidambar styraciflua, and species of oaks, also occur as undergrowth in the pine woods mixing with the species that are true shrubs. *Mingling especially with the young trees of coniferous or deciduous* growth is a great variety of shrubs: Myrica carolinensis, Vaccinium corymbosum, Rhus copallina, Aralia spinosa, Oxydendrum arboreum, Sassafras sassafras, Diospyros virginiana, while in heavy moist soils grow Amelanchier botryapium, Azalea canescens, Symplocos tinctoria, Ilex glabra. Kalmia latifolia, Styrax grandifolia, Vaccinium (Batodendron) arboreum are rare and local. As under shrubs beneath the larger shrubs are Vaccinium stamineum, V. vacillans, V. virgatum var. tenellum, Gaylussacia frondosa, Rubus hispidus (in moist low pine woods).

River Bluff Forest Formation. The mesophytic forest extends into the Altamaha Grit Region, according to Harper (loco citato), along the steep bluffs of the muddy rivers which cross it. Ninety percent of the plants that occur on these bluffs occur on the Piedmont plateau a large proportion finding congenial habitats in the cool shaded valleys of the Blue Ridge.

*Pine Barren Formations.* The pine forests extend from within a few miles of the sea coast inland to near the western limits of the coastal plain region. The pines of this formation are *Pinus palustris*, *P. Taeda*, *P. serotina*, *P. mitis* (= *P. echinata*). They are for the most part confined to the uplands, and form the dominant growth with broad-leaf trees beneath them, or occur as a pure growth. Other trees are *Taxodium distichum*, *Chamaecyparis thyoides*, *Juniperus virginiana*, all of which in the original forests are confined to the lowlands. Forests of pine covered, at least in their original distribution, all of the uplands, there being only a few local areas on which broad-leaf trees were not subordinate to them[1]). A very large part of eastern Virginia and North Carolina is pine land. In the vicinity of Washington, and especially in Maryland, *Pinus rigida* with *Pinus inops* (= *P. virginiana*) in similar situations is prominent (Pinus rigida Facies). As one proceeds southward, both of these species of the northern pine barrens become more rare, *Pinus rigida* almost completely disappearing before the Rappahannock River is reached. *Pinus Taeda* comes in around the margins of groves of *Pinus rigida*. Still further southward *Pinus rigida* seems to be worsted in the struggle by *Pinus Taeda*. Finally when the James River is reached, *Pinus Taeda* becomes

1) PINCHOT, GIFFORD and ASHE, W. W.: Timber Trees and Forests of North Carolina. North Carolina Geological Survey 1897, Bulletin 6: 149.

the prevailing pine (Pinus Taeda Facies)[1]. To the north of Tar River, except on the porous and highly silicious soils where pure and uninterrupted growths of *Pinus palustris* occurred, the original forests were composed of alternating belts of *Pinus mitis* (= *P. echinata*) (Pinus mitis Facies) and *Pinus Taeda* (Pinus Taeda Facies). *Pinus mitis* with a subordinate growth of broad-leaf trees, largely oaks, dominated the crests and grew on the drier and more gravelly soils; while on the lower, moister, loamy soils *Pinus Taeda* as a rule formed a pure growth sometimes associated with broad-leaf trees. *Pinus palustris* crosses the Roanoke River extending in small groves about as far north as the southeastern boundary of Virginia, a few trees occurring in the pine forests, as far, as Chesapeake Bay. The low pine barrens within the tide water area of the coast which consists of forests of *Pinus palustris* which occupy the poorly drained grassy flats are very open interrupted by swamps densely covered with cypress and other trees. The rolling pine lands, pine hills or pine barrens proper are the true home of *Pinus palustris*[2]. On the Atlantic coast these uplands rise to hills over 600 feet in height. Thus spreading out in extensive table-lands, these hills are covered exclusively with forests of *Pinus palustris* for many hundreds of square miles without interruption. Here it reigns supreme.

The forests of this tree in South Carolina follow more closely the coast line with an extension inland averaging 100 miles. In the low perfectly level pine barrens covered by *Serenoa serrulata*, *Pinus serotina*, and a stunted growth of *Pinus Taeda* and *P. cubensis*, *Pinus palustris* is rarely seen. In the flat woods bordering the alluvial swamps *Pinus palustris* becomes more frequent and finally prevails on the sandy ridges associated with *Quercus Catesbaei*, *Q. cinerea* and *Q. falcata*. In Georgia the pine barren proper forms a vast plain covered exclusively by *Pinus palustris* beneath which is the wire grass *Aristida stricta*. This area merges into the flat woods or savannas of the coast plain.

The Atlantic pine region extends into Florida between the Suwanee River and the Atlantic coast as far south as St. Augustine where *Pinus palustris* is less common and inferior in size being replaced by *Pinus caribaea* (= *cubensis*) which forms open forests associated with *Serenoa serrulata*, the saw palmetto (See plate VI at page 306). In the central section of the peninsula with its numerous lakes *Pinus palustris* is largely associated with the sand pine, *Pinus clausa*, and hard woods prevail on the upland hammock lands.

Near the edge of the Piedmont Plateau this forest merges into one of mixed growth. The short leaf pine *Pinus mitis* rather sparingly distributed in the pine barrens of the south. With the appearance of *Pinus palustris*

1) WARD, LESTER F.: Notes on the Flora of eastern Virginia. Botanical Gazette 1886 XI: 33.

2) MOHR, CHARLES: The timber Pines of the southern United States. Division of Forestry U. S. Department Agriculture 1896. Bulletin No. 13.

south of Virginia *Pinus mitis* recedes from the coast and is found chiefly in upper part of the southern coast pine belt. In Florida it is confined to the uplands along the northern border of the state scattered among *Pinus palustris*, and broad-leaved trees. *Pinus Taeda* in Virginia is not found beyond the northern limit of the Tertiary strata of the coast region and it occurs generally in the flat lands of the tidewater districts forming rarely continuous forests. In North Carolina, *Pinus Taeda* is the predominating tree throughout the eastern coast plain and in the lower part of the state where it forms extensive forests, more or less frequently interspersed with *Pinus palustris*. South of Cape Fear River however the latter prevails almost exclusively. In the extensive region watered by numerous streams flowing into Albemarle and Pamlico sounds, in the rich, moist soil of the wide swamps above tidewater, *Pinus Taeda* reaches its best development.

In general these pine forests resemble a two-storied high forest, there being an upper story of pine 70—100 feet in height, with a rather thin cover and beneath the pine an open growth of scrub oaks 10—15 feet in height. As the cover of the pines becomes thinner the oaks become more numerous. The floor is grassy with coarse tufts of Aristida stricta or broom grasses, or it is covered with shrubs.

In the Dismal Swamp Territory of Virginia the dry sandy soil of the open pine woods is provided with a more or less close carpet of grasses and other herbaceous plants. Grasses of the genera Andropogon, Panicum and Danthonia prevail with such herbs as Polygala mariana, Stylosanthes biflora, Psoralea pedunculata, Desmodium strictum, Elephantopus nudatus, Eupatorium linearifolium, Aster gracilis, Koellia hyssopifolia, Gratiola pilosa, Linum medium etc. In somewhat moister but otherwise very similar soil, species of Rhynchospora, Eupatorium rotundifolium, Rhexia mariana, Ascyrum stans, Bartonia virginica, Spiraea tomentosa, Ilysanthes gratioloides. Herpestis acuminata are characteristic [1]. In small depressions along streams, diminutive marshes are frequent and here grasses give place almost entirely to sedges; Rhynchospora inexpansa, R. corniculata, Cyperus pseudovegetus, Eleocharis tortilis, Carex verrucosa, as well as Juncus setaceus, Habenaria cristata, Trachelospermum difforme (a thin stemmed liana).

Southward, the pine barren formation becomes more and more the predominant element of the vegetation. The drier more open soil beneath *Pinus palustris*, the dominant tree, is occupied by *Aristida stricta*, *Ctenium americanum*, *Linum floridanum*, *Ludwigia virgata*, *Hypericum pilosum*, *H. virgatum*, *Rhynchosia tomentosa*, *Indigofera caroliniana*, *Zornia tetraphylla*, *Eupatorium pinnatifidum*, *E. rotundifolium*, *Solidago petiolaris* and species of *Lespedeza* and *Desmodium*. The lower marshy places are characterized by *Carex verrucosa*, *Dichromena leucocephala*, *Fuirena squarrosa*, *Hypericum galioides*, *Polygala lutea*, *Rhexia*, *Aster paludosus*, *Trilisa*, *Carphephorus*, *Solidago pulverulenta*, *S. pilosa* while in still wetter situations occur *Lycopodium alopecuroides*, *Habenaria blephariglottis*, *H. cristata*, *Sarracenia flava* and often species of *Sphagnum*.

In South Carolina two kinds of pine land may be distinguished: loblolly pine land and longleaf pine land. The loblolly pine Pinus Taeda occupies the fresh moist uplands extending

1) KEARNEY, THOMAS H.: Report on a botanical Survey of the Dismal Swamp Region: 405—406.

in places into the bottoms. The soil on this land is light, sandy loam with considerable admixture of clay. The under story of hardwoods may be dense or open and consists of Liquidambar styraciflua, Nyssa sylvatica, Acer rubrum, Quercus aquatica (= Q. nigra), and occasionally Fagus americana with a third layer of Persea carolinensis etc. The longleaf Pinus palustris is confined in the main to higher situations and to drier and lighter soils in South Carolina. On the drier parts of loblolly pine lands the two trees intermingle. Underbrush while not so plentiful as on loblolly pine lands is often present[1]. Stunted trees of Quercus falcata, Q. tinctoria and Q. obtusiloba occur.

There are several kinds of pine barrens botanically considered in Georgia[2], differing principally in the amount of water in the soil. First are the wet pine barrens in which the ground is usually covered with water a few inches to a foot, or so, in depth, occupied by the following species:

Rhynchospora corniculata Lam.
» Tracyi Britton.
Hypericum fasciculatum Lam.
Proserpinaca pectinata Lam.
Sabbatia gentianoides Ell.
Gratiola quadridentata Mx.
Pontederia cordata L.
Stillingia aquatica Chapm.
Ilex glabra L.
Herpestis (Monniera) caroliniana Walt.
Utricularia purpurea Walt.
» juncea Vahl.
Lobelia Nuttallii R. & S.
Sclerolepis uniflora Walt.

In the moist pine barrens where there is no standing water on the surface the species are more numerous, the following being a partial list of them:

Lycopodium alopecuroides L.
Taxodium imbricarium Nutt[3].
Rottboellia (Manisuris) rugosa Nutt.
Dichromena latifolia Baldw.
Rhynchospora axillaris Lam. (= R. cephalantha A. Gray).
» microcarpa Baldw.
Tofieldia (Triantha) racemosa Walt.
Aletris aurea Walt.
Lachnanthes tinctoria Walt. (= Gyrotheca capitata Walt.).
Habenaria nivea Nutt.
Spiranthes (Gyrostachys) praecox Walt.
Calopogon pulchellus R. Br. (= Limodorum tuberosum L.).
Sarracenia variolaris Michx. (= S. minor Walt.).
Polygala cymosa Walt.
Ilex myrtifolia Walt.
Hypericum myrtifolium Lam.
» virgatum Lam.
Rhexia glabella Michx.
Hydrocotyle (Centella) repanda Pers.
Gerardia linifolia Nutt.
Sabbatia paniculata Michx.
» campanulata L.
Acerates floridana Lam.
Breweria aquatica Walt.
Rudbeckia Mohrii Gray.
Aster adnatus Nutt.
Coreopsis nudata Nutt.

The pine barrens are characterized by a great variety of herbaceous plants with showy flowers displayed especially in early autumn, when the gay colors of many Compositae are everywhere a feature of the landscape.

In the Altamaha Grit Territory, according to Harper, as we pass down the slopes of any of the low ridges, we pass gradually into pine barrens perceptibly moist. This transition strip may be designated as the intermediate pine barrens and here are found some species which are rare or wanting in both adjacent strips, viz., the dry pine barrens and the wet pine barrens. Here occur Pinus palustris, P. serotina, P. caribaea (= P. Elliottii, P. bahamensis), Kalmia hirsuta,

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1) CHAPMAN, CHARLES S.: A working Plan for forest Lands in Berkeley County, South Carolina. Bureau of Forestry Bulletin 56. 1905: 7—10.

2) HARPER, ROLAND M.: Notes on the Flora of South Georgia. Bulletin Torrey Botanical Club XXVII: 413—436. August 1900.

3) HARPER, ROLAND M.: Bulletin Torrey Botanical Club 1902 XXXIX 383—399.

Serenoa serrulata, Ilex glabra, Vaccinium nitidum, Gaylussacia frondosa, G. dumosa, Quercus pumila, Myrica cerifera var. pumila, Hypericum opacum, H. myrtifolium etc. Perennial herbs predominate and the trees belong to the genus Pinus. Most of the shrubs are evergreen and there seem to be no vines or parasites.

The dry pine barren occupies the summits and upper slopes of all the ridges and constitutes at least half the area of the whole Altamaha Grit. Only four or five herbaceous vines occur and the adoptations of many of the plants is to reduce transpiration. Flowers seem to be most abundant in June. The flora of these barrens consists of Pinus palustris associated with Quercus cinerea, Q. Catesbaei, Q. marylandica, Q. falcata, Q. Margaretta, Diospyros virginiana, Ceanothus etc.

Central peninsular Florida is a lake region. There are five well marked areas, the flora of each being different, viz., high pine land, scrub land, low pine land, bay heads and hammocks. The high pine land is covered by *Pinus palustris* associated with *Quercus Catesbaei*, *Q. cinerea*, *Ilex glabra* and *dahoon*, *Andromeda* (*Pieris*) *nitida*, *A. speciosa*, while on the ground underneath are many herbaceous plants [1]).

The scrub flora is different and antagonistic to that of the high pine land. *Pinus clausa* is the prevailing tree. *Ceratiola ericoides* occurs abundantly, as also *Persea humilis*, *Bumelia lanuginosa*, *Ximenia americana*, *Breweria grandiflora*, *Rhynchospora dodecandra*, while *Smilax Beyrichii* climbs all over the scrub oaks and is the only one of this genus observed growing in the scrub.

The flora of the low pine land is not so distinct because it grades into that of the high pine land. *Pinus serotina*, *P. caribaea* (= *P. cubensis* = *P. heterophylla*) are the prevailing trees. Some of the species peculiar to this formation are *Podostigma pedicellata*, *Bejaria racemosa*, *Rhexia ciliosa*, *R. serrulata*, *Bletia verecunda*, *Aristida stricta* and *Andropogon floridanus*.

Where the clay tops the sand, hammocks occur. *Quercus virginiana* (= *Q. virens*) is the principal tree with *Sabal Palmetto* (see plate IX) on the trunk of which grow *Polypodium incanum* and *Vittaria lineata*, associated with *Sabal Adansonii*.

Hammock Formation. In east Florida the vegetation of the hammocks consists of Lobelia Cliffortiana, Vicia micrantha, Ilysanthes grandiflora, Micromeria Brownei, Eryngium Baldwinii, Samolus valerandi var. americanus, Nephrodium (Aspidium) patens, Blechnum serrulatum and as epiphytes Tillandsia juncea. T. utriculata. Along meandering streams are dense thickets composed of Chionanthus virginicus, Magnolia glauca, Aronia (Pyrus) arbutifolia var. erythrocarpa, Amorpha fruticosa, Bignonia capreolata, Leucothoë racemosa, Decumaria barbara and Smilax Walteri [2]).

Probably to be included in this formation are the sand hammocks of the Georgia Altamaha Grit Region described by HARPER. The soil of these hammocks is Columbia sand mixed with varying amounts of humus. The higher hammocks perhaps resemble the "scrub" of Florida. The constituent plants are Quercus Catesbaei, Q. laurifolia, Magnolia grandiflora, Ilex opaca, Osmanthus americana, Pinus palustris (higher ground), P. glabra, Cornus florida, Hamamelis virginiana, Gelsemium sempervirens, Asimina parviflora, Amelanchier canadensis etc. Here the pro-

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1) NASH, GEO. V.: Notes on some Florida Plants. Bulletin Torrey Botanical Club XXII: 144—147.

2) GARBER, A. P.: Botanical Rambles in east Florida. Botanical Gazette 1877 II: 70, 102.

**Black Gum Swamp** along **Governors Creek, Florida**
*consisting of Nyssa biflora* Walt., N. *uniflora* Wang., Magnolia glauca L. draped with Tillandsia.
Photograph by William Rau.

portion of vines and epiphytes is large and the herbs are most by perennial. The flowering period in the hammocks, according to HARPER (A phytogeographical Sketch of the Altamaha Grit Region. Annals of the New York Academy of Sciences XVII, Part I: 101) is the latter part of March.

*Hydrophile Forest Formations.* In Virginia and North Carolina by far the greater part of these formations is embraced within the limits of the great Dismal Swamp proper. Two principal formations may be distinguished: (1) the Black Gum Swamp Formation consisting of heavy deciduous forest; and (2) the White Cedar Swamp Formation which is light open and originally in great part covered with an evergreen forest of white cedar *Chamaecyparis thyoides* called locally juniper, but now in many places almost destitute of trees and bearing a growth of shrubs, of cane (*Arundinaria macrosperma*) and of ferns and peat moss.

Black Gum Swamp Formation (see plate X). According to my observations, the black gum *Nyssa biflora* is predominant associated with the prevailing conifer *Taxodium distichum*, *Pinus Taeda* comparatively scarce and unimportant. Such a deciduous forest alone occupies the low, flat banks of rivers and it is likewise characteristically developed within the Great Dismal Swamp about Lake Drummond. At all seasons, the soil is nearly or quite saturated.

Nyssa biflora and Acer rubrum are the most abundant trees with Nyssa uniflora, Fraxinus platycarpa (= F. caroliniana), Quercus phellos. Among small trees Magnolia glauca, Persea pubescens, Carpinus caroliniana, Salix nigra, Alnus rugosa while Populus heterophylla is rather frequent in the smaller swamps along streams. Near the eastern border of the Dismal Swamp where Pinus Taeda is most abundant. The tulip tree Liriodendron tulipifera and the sweet gum, Liquidambar styraciflua occur in the deciduous forested swamp and are often of considerable size [1]). A peculiarity of Taxodium distichum, Nyssa biflora and Fraxinus caroliniana in these swamps is the enlarged base of the tree trunk where it is sometimes submerged and the "knees" of Taxodium may be looked upon in the nature of aerating organs. Many woody lianas occur and drape the larger trees, viz., Berchemia scandens, Gelsemium sempervirens, Bignonia capreolata, Vitis labrusca, Smilax rotundifolia, S. Walteri, S. laurifolia (in open swamp), Clematis crispa. Two epiphytes occur on the branches of Taxodium in open light situations: Polypodium incanum, Tillandsia usneoides. A woody parasite, Phoradendron flavescens, is abundant upon the branches of Nyssa biflora and Acer rubrum. On old logs in the swamps grow Tipularia unifolia, Gaultheria procumbens, Mitchella repens, liverworts and mosses.

The prevailing undergrowth in the more open places consists of Leucothoë axillaris, Clethra alnifolia, Arundinaria macrosperma and in places such ferns as Woodwardia areolata, Osmunda regalis, O. cinnamomea, and according to my observations, Saururus cernuus along streams in the Dismal Swamp forms pure associations. In places where the ground is rather high notably upon the eastern shore of Lake Drummond, the following perennial herbs are abundant; Boehmeria cylindrica, Polygonum arifolium, Scutellaria lateriflora, Lycopus rubellus, Eupatorium purpureum, Impatiens fulva and Woodwardia areolata. The rare Pinckneya pubens occurs in such swamps in South Carolina.

Generally speaking the gum, or cypress swamps occupy the deepest parts of nearly all the swamps in the coastal region which have a sufficiently porous

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1) KEARNEY, THOMAS H.: Report on a botanical Survey of the Dismal Swamp Region. Contributions U. S. National Herbarium 1901 V: 419.

soil to permit the penetration of the deeply seated cypress roots and which are not subject to drying out in the late summer. The trees are all shade enduring in their youth and probably with the exception of water gum *Nyssa biflora* all shade demanding in the earliest seedling stages.

In South Georgia [1]) the following species are found in alluvial woods and swamps and on muddy banks of creeks and rivers subject to overflow.

Taxodium distichum L.
Juniperus virginiana L.
Carpinus caroliniana Walt.
Populus monilifera Ait. (= P. deltoides Marsh.).
Quercus lyrata Walt.
» Michauxii Nutt.
Fraxinus americana L.
» caroliniana Mill.
Liriodendron tulipifera L.
Nyssa uniflora Wang.
Chionanthus virginicus L.
Leucothoë racemosa L.
Ilex opaca Ait.
Berchemia volubilis DC. (= B. scandens Hill.).
Clematis crispa L.
Tecoma radicans L.
Sabal Adansonii Guerns. (= S. glabra Mill.).
Arundinaria macrosperma Michx.
Tillandsia usneoides L.
Iris versicolor L.
Hydrocotyle verticillata Thunb.
Peltandra virginica L.
Commelina hirtella Vahl.
Scirpus divaricatus Ell.
Rhynchospora corniculata Lam.
Saururus cernuus L.
Boehmeria cylindrica L.
Dianthera americana L.
Conoclinum coelestinum L.
Pluchea petiolata Cass.
Lobelia cardinalis L.
Botrychium obliquum Muhl.

This formation exists in the Altamaha Grit Region of Georgia (Harper loco citato) in the branch swamps occupying the troughs of the streams, small rivers and creeks. There is a wide diversity in these swamps (as to be seen in comparing the preceding plant list) and the constituent plants vary with the character of the stream and valley bottom) but the following plants are characteristic of such swamps:

Pinus caribaea (= P. Elliottii, P. bahamensis).
» serotina.
» Taeda.
Taxodium imbricarium.
» distichum.
Acer rubrum.
Liquidambar styraciflua.
Nyssa biflora.
» Ogeche. (N. capitata).
» uniflora. (linensis).
Persea pubescens (= P. carolinensis).
Planera aquatica.
Gordonia Lasianthus.
Pinckneya pubens.
Viburnum nudum.
Clethra alnifolia.
Cyrilla racemiflora.
Cliftonia ligustrina (= C. monophylla).
Leucothoë racemosa.
Berchemia scandens.
Phoradendron flavescens.
Wistaria frutescens.
Rhus radicans.
Iris versicolor.
Orontium aquaticum.
Sarracenia flava.
Sabal Adansonii.
Serenoa serrulata.
Smilax laurifolia.
» Walteri.
Eriocaulon lineare.
» decangulare.
Tillandsia usneoides.
Isoetes flaccida.

The aspects of the vegetation of Okefinokee Swamp, Georgia [2]) seem to depend on the distance of the sandy bottom below or above the water level. When the sand rises above the

1) Harper, Roland M.: Notes on the Flora of south Georgia. Bulletin Torrey Botanical Club XXVII: 413—436. Aug. 1900.

2) Harper, R. M.: Popular Science Monthly 1909: 606.

water level, islands are formed upon which grow Pinus caribaea, P. serotina, Serenoa serrulata. These islands are surrounded by swamps in which Taxodium imbricarium and Pinus caribaea are dominant, the pine dissappearing when the pond muck is three or four feet deep. Beneath the trees in the sphagnum grow Woodwardia virginica, Sarracenia variolaris = minor, S. psittacina. The trees are draped with Tillandsia usneoides while Andromeda (Pieris) phillyreifolia ascends the trees to a height of 30 feet by insinuating stems between the outer and inner layers of the bark. Where the sandy bottom lies six feet below the water level wet savannas (prairies) are formed in which the bulk of the vegetation consists of Panicum digitarioides, Orontium, Pontederia, Nymphaea odorata while the surface is marked by cypress clumps with evergreen vines and shrubs called 'bouses' because hunters camp in them.

White Cedar Swamp Formation. This formation usually known locally as juniper swamp is most characteristically developed in the outer portion of the Great Dismal Swamp. The prevailing tree is the white cedar, *Chamaecyparis thyoides* (= *sphaeroidea*). The cedar swamp is usually not so wet as the black gum swamp and it has a substratum of a red brown peat composed largely of the stems, leaves and roots of *Chamaecyparis* and often buried logs in a remarkable state of preservation. Where undisturbed it forms pure associations consisting besides of *Magnolia glauca*, *Persea*, *Ilex opaca*, *Acer rubrum*, *Nyssa*, as subordinate species. On somewhat higher ground *Quercus aquatica* (= *Q. nigra*), *Q. Michauxii*, *Fagus americana* invade land formerly occupied by white cedar.

### 4. Swamps and Marshes.

Arundinaria (Canebrake) Association. In the open parts of the swamps is the canebrake which covers extensive areas often in nearly pure association where the shrubby growth has not secured the upper hand[1]). The cane *Arundinaria macrosperma* grows to a height of two meters (over 6 feet) although along ditches it may grow taller. The plant spreads rapidly by means of its creeping, much branched rhizomes.

Woodwardia-Sphagnum-Association. The open parts of swamps are not always canebrake, occasionally a large fern *Woodwardia virginica* prevails usually on low tussocks surrounded by standing water. The fronds often measure four feet (12 dm.). Associated with this fern are: *Eriophorum virginicum*, *Calopogon pulchellus*, which with the fern grow out of a bed of *Sphagnum cymbifolium* var. *glaucescens* and its form *squarrulosa.*

The large swamps in Florida lying generally along the low pine land have a peculiar flora. These swamps are known locally as "bayheads". A large number of trees of *Magnolia glauca*, occur in them associated with *Andromeda nitida*, *Leucothoë racemosa*, *Gordonia lasianthus* with *Smilax laurifolia* climbing over all the shrubs and bushes. Here and there are open places where sphagnum grows in quantity and *Utricularia fibrosa*, *Peltandra sagittaefolia*, while *Andropogon brachystachyus* is locally distributed in the vicinity and is found no where else.

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1) KEARNEY, l. c. p. 427.

## Fresh Water Marsh Formation.

These formations are frequent in the southern states where so many rivers rising in the mountains flow eastward and southeastward to meet the ocean. Briefly we may distinguish the following formations and associations.

*Reed Marsh Formation.* This is typic along rivers in Virginia and elsewhere. — Typha-Sagittaria Association. The larger rivers are fringed by a narrow belt of marsh vegetation which merges into salt marshes down stream and into the wooded swamps above. Such trees as *Taxodium distichum*, *Acer*, *Magnolia*, *Salix nigra* occur associated with bushes of *Alnus rugosa*, *Salix longipes*, *Itea*, *Rosa carolina*, *Clethra* and with certain lianas (*Smilax*, *Berchemia*, *Clematis*). The outermost growth in water 6—10 inches (15—30 centimeters (deep is most often denominated by *Typha latifolia*, *Sagittaria lancifolia*, *Pontederia cordata*, while *Scirpus lacustris*, *Zizania aquatica*, *Sium cicutifolium*, *Polygonum hydropiperoides* are ordinarily abundant elements in this association. *Acorus calamus* sometimes grows in almost pure association, while in limited areas *Juncus effusus* fringes open water as does *Dianthera americana* in other places infested with *Cuscuta Gronovii*.

Scirpus-Erianthus Association. The edges of the hydrophile forest are occupied by an association in which *Scirpus cyperinus* var. *eriophorum* is the most important element with *Erianthus saccharoides*, *Typha*, *Andropogon glomeratus*, *Woodwardia* and *Arundinaria tecta*. — Along the ditches and pools in the heart of the Dismal Swamp *Dulichium arundinaceum* and *Triadenum virginicum* are abundant in the shallow water.

*Low Marsh Formation.* This formation includes the limited areas of marshy ground or swales in the forested plain which are chiefly covered with a low rather than a tall reedy growth. — Rhynchospora-Eleocharis Association. The vegetation of the low marshes in Virginia comprises a great variety of species among which occur: *Rhynchospora cymosa*, *R. inexpansa*, *R. glomerata*, *R. corniculata*, *Eleocharis ovata*, *E. tortilis*, *Carex verrucosa*, *Fimbristylis autumnalis*, *F. laxa*, *Lipocarpha maculata*, *Fuirena squarrosa*, *Cyperus-Juncus*-species, *Xyris caroliniana* and *ambigua*. Grasses mostly with weak stems are often an important element: *Glyceria pallida*, *Panicum gibbum*, *P. verrucosum*, *P. viscidum*.

*Aquatic Formations.* This unlike most of the other formations presents no clearly defined associations corresponding to topographic conditions. On the contrary, the distribution of aquatic plants seems to be largely determined by accidents of dissemination. The greater part of the aquatic vegetation occupies lakes, ponds, open ditches, river channels and bayous throughout the region. *Elodea canadensis* grows in the swifter reaches of the streams. *Myriophyllum heterophyllum*, *Nymphaea odorata*, *Utricularia purpurea*, *U. inflata*, *Callitriche heterophylla* are among the most common aquatics of the region. *Riccia fluitans*, often growing terrestrially, is abundant. *Ludwigia* (*Isnardia*) *palustris*, *Juncus repens* are also aquatic marsh plants. — Ponds in Georgia are surroun-

ded by *Taxodium imbricarium*. The aquatic vegetation of these consists of *Cabomba*, *Brasenia*, *Nelumbo*, *Nymphaea odorata*, *Nuphar advena* which associated with *Limnanthemum aquaticum* cover the surface of the water very densely [1]).

These ponds in the Altamaha Grit Region are characterized by a rather dense growth of pond cypress, Taxodium imbricarium, associated with Pinus caribaea, Nyssa biflora, Ilex myrtifolia, Pontederia cordata, Ludwigia pilosa, Saururus cernuus, Lobelia Boykinii, Proserpinaca pectinata, P. palustris, Sphagnum macrophyllum etc. Perennial herbs are here much more abundant than woody plants and the cypress exceeds all other vegetation combined. Ludwigia pilosa often has spongy tissue several times as thick as the rest of the stem. The number of flowers is greatest in midsummer. In the shallower pine barren ponds, while not essentially distinct from the cypress ponds, the number of cypress trees is very materially reduced until in some places this tree entirely disappears.

Originally many of the rivers in Florida were characterized by floating masses of *Pistia stratiotes*, but recently the original aquatic vegetation of some of the principal rivers notably the St. Johns and tributaries has been almost exterminated by the appearance and spread of the water hyacinth *Eichhornia crassipes* (= *E. speciosa*), a plant introduced about 1890 at Edgewater about four miles above Palatka. This plant has spread so rapidly and grows in such dense masses, as seriously to impede the navigation of those streams where it is found [2]).

## C. Gulf Pine Barren-Strand District.

This district includes the coastal plain from the lower course of the Suwannee River west and southwest to the subtropic littoral of the Texan coast. It merges imperceptibly into the Atlantic coast district on the one hand and into the subtropic Tamaulipas region in Texas and northeastern Mexico on the other. It is considered as distinct from either of these districts for purposes of convenience, and also, because there are quite a number of plants peculiar to the Gulf coastal plain, or which reach their most pronounced development or most extensive range in this portion of the continent.

No observations are at hand concerned with the plankton and the marine algal associations of the Gulf coast. The strand flora, however, is comparatively well known from the researches of Charles Mohr [3]) R. S. Cocks and those of Francis E. Lloyd and S. M. Tracy [4]).

1) Harper, Roland M.: Botanical Explorations in Georgia during the Summer of 1901. Bulletin Torrey Botanical Club 1903 XXX: 290.

2) Webber, Herbert J.: The water Hyacinth and its Relation to Navigation in Florida. Division of Botany U. S. Department Agriculture Bulletin 18. 1897.

3) Mohr, Charles: Plant Life of Alabama. Contributions from U. S. National Herbarium VI: 129.

4) Cocks, R. S.: The Flora of the gulf biologic Station. Bulletin 7 issued by the La. State Board of Agriculture and Immigration 1907 with a short history of botany in Louisiana and the only complete list of La.-plants. Lloyd, Francis, E. and Tracy, S. M.: The insular Flora of Mississippi and Louisiana. Bulletin Torrey Botanical Club XXVIII: 61—101. March 1901.

### 1. Strand, Sand Plain- and Low Flat-Formations.

*Beach Formation.* The sandy flat beach in Alabama is almost destitute of vegetation. The upper beach is characterized by *Ipomoea pes-caprae. Sesuvium portulacastrum* (in shallow salty pools) with *Cakile maritima geniculata*, both frequent in the West Indies, associated with *Iva imbricata*, *Suaeda linearis* and in Louisiana *Salicornia ambigua* and *Heliotropium curassavicum*. The snow white sand along the shore of Mobile Bay and the land-locked Perdido Bay are covered by a scattered growth of grasses: *Panicum repens*, *Stenotaphrum secundatum*, *Cenchrus incertus* and *tribuloides* var. *macrocephalus*, *Tricuspis* (*Triodia*) *purpurea*. A small group of small shrubs herbaceous plants (*Euphorbia*, *Froelichia*, *Paronychia* etc.) mingle on the sandy benches with the above, viz., *Chrysoma* (*Solidago*) *pauciflosculosa* [1]), *Conradina canescens*, *Polygonella polygama*, *Helianthemum arenicola.*

The middle beach in Mississippi and Louisiana is occupied by Suaeda (Dondia) linearis, Cakile fusiformis, Salsola Kali, Cenchrus tribuloides var. macrocephalus, Sesuvium portulacastrum, Euphorbia polygonifolia, Oenothera humifusa, Erigeron repens, Heterotheca subaxillaris, Eragrostis secundaeflora, while inside of these are found Ipomoea pes-caprae, I. acetosifolia, Strophostyles helvola, Canavalia obtusifolia. The upper beach association may at times consist wholly of three plants: Panicum amarum, Ipomoea pes-caprae, I. acetosaefolia. Associated with Panicum amarum is Uniola paniculata, which on the east coast of Florida and northward is predominat, while on the Gulf coast it becomes of secondary importance, Panicum amarum becoming the leading grass. Yucca gloriosa occurs on the beach dunes.

The strand vegetation of Texas, according to BRAY, consists of the tropic salt grass Monanthochloë littoralis, forming a dense mat, Salicornia mucronata (= S. Bigelowii), S. ambigua (on compoet wet sands), while Borrichia frutescens and Lycium carolinianum are shrubs that grow on the crest of the beach.

*Delta Formation.* The "passes" of the Mississippi River are broad channels of fresh water separated from the waters of the Gulf by an irregular and frequently narrow strip of land of river deposit. Two associations of plants may be recognized. These are the Phragmites-Vigna- and the Spartina-Associations, according to LLOYD and TRACY [2]). The former occupies the higher levels and, therefore, the portion of the alluvial bank near the fresh water. *Phragmites communis* (= *P. phragmites*) and *Vigna glabra* are prominent associated at times with *Salix nigra* and vines of *Cissus* (*Ampelopsis*) *arborea*. In the swampy ground of the lower levels which border on the salt water *Spartina polystachya* gives character to the vegetation.

*Dune Formation.* Hillocks of drifting white sand rise above the beach in Alabama. On these dunes *Quercus virginiana* makes a scrubby growth associate with the sand oak *Quercus myrtifolia*. These with *Ceratiola ericoides*, *Chrysoma*, *Polygonella* intertwined with *Smilax auriculata* form an association of evergreen bushes. *Uniola paniculata* grows on the crests and steep sides

1) LLOYD, FRANCIS E.: Some Points in the Anatomy of Chrysoma pauciflosculosa. Bulletin Torrey Botanical Club XXVIII: 445.

2) LLOYD, FRANCIS E. and TRACY, S. M.: The insular Flora of Mississippi and Louisiana. Bulletin Torrey Botanical Club XXVIII: 80. March 1901.

of the dunes associated with *Opuntia pes-corvi* and *Siphonychia erecta*. The dead tops of *Pinus clausa* and buried trunks of *Yucca aloifolia* covered by the drifting sand heighten the impression of aridity. In Mississippi and Louisiana the wandering dunes are frequently captured by thickets of *Ilex* and *Myrica gale*. Other dunes show on their windward slopes a vegetation of annuals and perennials composed chiefly of *Iva imbricata*, *Serenoa serrulata* with occasional clumps of *Uniola* and *Siphonychia*. These dunes are in rapid motion and have left behind them a "graveyard" of dead pines.

The crests of the barrier islands along the Gulf coast of Texas, according to the researches of BRAY[1]) are composed of unstable sand dunes. In front of this crest the compact beach sands slope to the surf line, while on the shore side, the islands slope away to the marsh tide flats or lagoons, or a succession of older dunes tenanted by salt plants, prairie grasses, *Yucca Treculeana*, *Prosopis juliflora*, *Celtis occidentalis*. On Brazos Island, the unstable dune crests are held by *Uniola paniculata*, so that as the sand blows away hay-cock dunes are formed.

*Sand Plain Formation.* Physiographically the sand plain consists of (1) shallow depressions generally wet; (2) low dunes; (3) level stretches of sand. The shallow basins are tenanted by a species of *Hydrocotyle* and *Mollugo verticillata*. The dunes are formed by *Panicum repens* and *halophilum*, *Iva*, *Serenoa*, while extending between the elevations and depressions are plants which do not produce a network of roots and stems, viz., *Scirpus*, *Cyperus*, *Diodia*, *Syntherisma*, *Cenchrus*. Open grass plains exist in these places characterized by a plant covering of a large number of herbaceous species of low stature with such grasses as *Chaetochloa magna*, *Uniola paniculata* and certain slender vines. Another type of sand plain is the forest-covered area found only on the larger islands of the Mississippi Sound. Broadly speaking the whole area is covered by a forest of pines of two species, *Pinus palustris* (= *P. australis*), *P. Taeda* with *Sabal Adansonii* and *Serenoa* as prominent elements in the undergrowth. Old long captured dunes are occupied by *Quercus geminata* and *Q. virginiana* whose trunks are clothed by *Ramalina*.

Shell Strand Formation. On the shore of the sea of the mainland and smaller islands along the banks of the bayous are heaps of bivalve shells 6 to 15 feet and over in height the accumulation of refuse from the food supply which served a race of men unknown to history. In Alabama large live oaks Quercus virginiana, Magnolia sp., Carya porcina (= Hicoria glabra) cover these heaps of shells together with dense copses of Aesculus pavia, Rhamnus caroliniana. The West Indian red cedar, Juniperus barbadensis here reaches perfection but elsewhere in exposed situations it becomes low and stunted. Thurberia arkansana is typic of these shell heaps from South Carolina to Texas. Evolvulus alsinoides widely distributed in the tropics has been observed on the shell deposits of Dauphin Island.

*Salt Marsh Formation.* The low islets along the Alabama coast and elsewhere along the Gulf coast are bare of tree growth and their soil is soaked by the

1) Distribution and Adaptation of the Vegetation of Texas. Bulletin University of Texas No. 82 Scientific Series No. 10, 1906: 106.

briny sea. Near Lake Pontchartrain in Mississippi salt marshes are common. Where sand and shingle are raised above continuous overflow occur evergreen shrubs preferring a saline soil: *Iva frutescens*, *Baccharis halimifolia* and *angustifolia*, *Chenopodium Berlandieri*, *Lycium carolinianum*, *Batis maritima*, *Salicornia* with *Fimbristylis spadicea* form a dense close cover and near the Mississippi mouth with the addition of *Spartina patens* and *stricta*. The black mangrove *Avicennia nitida* with its well known pneumathodes grows abundantly on some islands in the muck marshes.

The shallow inlets of the sea in Alabama with their floor of deep sandy mud are covered exclusively by *Juncus Roemerianus* (see ante p. 428). This rush forms the great bulk of the vegetation of the saline marshes associated with *Fimbristylis*, *Spartina polystachya*, *Cladium effusum* etc. In higher situations the rushes and grasses disappear and more or less open associations of low perennials and herbaceous plants grow in the damp ground which is covered by a salty efflorescence.

The low Texas coast throughout most of its extent is shielded from the Gulf by a series of sand islands which front a series of lagoons and salt marshes tenanted by such salt grasses as *Spartina junciformis*, which according to J. G. SMITH forms fully ninety percent of the vegetation of the marsh together with *S. patens*, *S. cynosuroides*, *Sporobolus*, *Distichlis* and *Monanthochloë littoralis* which forms the seaward edge of the marsh.

## 2. Forest Formations.

*Low Flat Pine Barren Formation*. These formations occupy the second terrace of the lowlands of the coast rising to a height of from 10—30 feet above the low flood plains and river bottoms and consisting of sandy loams.

Open forests of *Pinus palustris* sparsely intermixed with *Pinus caribaea* (= *P. heterophylla* = *P. cubensis*) and *P. Taeda* covered this plain. *P. palustris* when removed was succeeded by *P. caribaea* which occupies the clearings. The ground is covered by a dense sod of low perennial monocotyledonous plants which upon decomposing yield a rather peaty soil in a semiboggy condition in rainy weather. Here grow *Sphagnum imbricatum*, *S. compactum*, able to resist occasional droughts. The plants typic of this association are *Rhynchospora plumosa*, *pusilla*, *cymosa*, *Kobresia odorata*, *Juncus Elliottii* and *marginatus*, *Andropogon Mohrii*, *Paspalum praecox*, *Rottboellia corrugata* (= *Manisuris rugosa*).

The spring plants are Bartonia verna, Houstonia patens, Chaptalia semifloscularis, Pinguicula lutea, P. pumila, Lupinus villosa, Helianthemum carolinianum, Drosera capillaris, D. brevifolia, D. Tracyi, Euphorbia inundata, Polygala lutea, P. polygama, Calopogon multiflorum. During the summer the flowers of the following plants are seen: Linum floridanum, Polygala Chapmani, P. Hookeri, Zygadenus glaberrimus, Habenaria nivea, Ludwigia hirtella, L. linearis, Eryngium yuccifolium, E. synchaetum, Sabbatia gentianoides, Gerardia paupercula, Ascyrum stans, A. crux-Andreae. In autumn appear, Helianthus heterophyllus, Solidago stricta, Baldwinia uniflora, Eupatorium leptophyllum, E. pubescens (= E. rotundifolium var. ovatum), Trilisa odoratissima. Ophioglossum crotalophoroides, Lycopodium carolinianum are typic plants of the coast plain.

*Hammock Formation.* There are more or less extensive tracts of black soil generally well drained skirting the lower river swamps or the low swamps of tide water. In these hammocks occur *Quercus virginiana* (= *Q. virens*), *Magnolia* sp. associated with *Pinus caribaea*, *P. Taeda*, *Quercus laurifolia* and *Q. aquatica*, *Fagus* and many small trees and shrubs (as *Osmanthus americana*, *Ilex*, *Myrica cerifera*, *Xanthoxylum*, *Prunus*, *Pirus*, *Crataegus*, *Chionanthus*, *Vaccinium arboreum*. Vines of *Vitis* (*Muscadinia*) *rotundifolia*, *Brunnichia cirrhosa*, *Cissus* and *Smilax* add to the maze of shrubs in the low hammocks. *Apteria setacea* is confined to the rich mold of the hammocks.

The shady borders of the hammocks are marked by the presence of Nemophila microcalyx, Asarum arifolium, Zephyranthes atamasco, Lupinus villosus, Rhexia mariana, R. lanceolata, Agrimonia incisa, Amorpha glabra, Sanicula canadensis, Panicum gibbum; Oplismenus hirtellus, Arundinaria tecta etc.

Where the hammocks merge into the alluvial lands, the soil becomes of a semi-swampy character. Here Halesia diptera, Cliftonia ligustrina. Cornus stricta, Cyrilla racemiflora, Ilex cassine, Sabal Adansonii, Andromeda nitida, Leucothoë axillaris form the thicket, while as lianas occur Decumaria barbara, Wistaria frutescens, Lonicera sempervirens, Gelsemium sempervirens. Nephrodium (Aspidium) patens is confined exclusively to the hammocks accompanied by Polystichum acrostichoides, Pteris aquilina, Asplenium ebeneum, Woodwardia angustifolia and virginica, Lycopodium cernuum. In the deepest recesses of the hammocks on the limbs of old magnolia trees is found Epidendrum conopseum.

*Pine Barren Swamps and -Ponds.* The swamps where the pine barren streams overflow their low banks of shifting sand and gravels have the same general tree covering as the pine barrens proper. When the soil is more deeply submerged, *Chamaecyparis thyoides* and *Taxodium imbricarium* prevail over the trees. Where the water is more shallow the botanist finds *Osmanthus americanus*, *Myrica inodora*, *Ilex ambigua* while in many places between the trees are *Mayaca Michauxii*, *Osmunda* and *Woodwardia.*

In the stagnant water of ponds flourish *Nymphaea odorata*, *Brasenia peltata*, *Limnanthemum lacunosum*, *Cabomba caroliniana*, *Nuphar advena*, *Potamogeton*, *Utricularia*, *Spirodela*, *Lemna.* The main channel of pine barren streams is inhabited by floating plants; other aquatics are *Fontinalis disticha*, *Hydrochloa fluitans*, *Nuphar sagittaefolium*, *Utricularia purpurea*, *Orontium aquaticum* and *Scirpus cylindricus.* The fresh water estuaries of the rivers are characterized by a submerged vegetation consisting of *Zannichellia*, *Ruppia*, *Ceratophyllum*, *Potamogeton* etc.

In Texas the most conspicuous and constant plant of these ponds is the spider lily *Hymenocallis occidentalis* and rattle bush *Daubentonia longifolia.* The cane grass *Arundo donax* occurs as a river bank species along the Rio Grande to the mouth of the Pecos and above the canyon part of the latter stream it forms a dense bank jungle.

Other herbaceous associations are found in the open river marshes. Reed-like grasses, large rushes and tall umbelliferous plants are characteristic of these swamps. Among these marsh plants are: Phragmites communis, Spartina polystachya, S. cynosuroides, Zizania aquatica, Scirpus lacustris, S. Olneyi, S. fluviatilis, Cladium effusum, Typha latifolia, Cicuta maculata, Tiedemannia

teretifolia, Sium cicutaefolium while below and covering the soil as secondary species of this association are: Cyperus erythrorhizos, C. strigosus, Carex lurida, C. alata, Rhynchospora caduca, R. corniculata while intermixed are Sagittaria montevidensis, S. latifolia, Pontederia cordata, Ipomoea sagittata, Kosteletzkya virginica, Boltonia diffusa, Vernonia gigantea, Lythrum lineare, Rumex altissimus. The dark waters of ditches and shallow pools at the outskirts of these marshes are filled with the floating stems of Jussiaea diffusa and bordered by Hydrocotyle ranunculoides, *H. verticillata, Ranunculus sceleratus, Discopleura capillacea, Aeschynomene virginica.*

*Cypress Swamp Formation.* Where the banks of the rivers and their deltas are perpetually submerged they are covered by the cypress, *Taxodium distichum.* Associated with Taxodium in Alabama are *Nyssa aquatica*, *Fraxinus platycarpa* (= *F. caroliniana*). Slightly above the level of long-continued overflows hardwood trees mingle with the cypress (*Nyssa biflora*, *Quercus aquatica*, *Carya* [*Hicoria*] *aquatica* etc.) and form the high forest overshadowing *Planera aquatica*, *Acer rubrum*, *Carpinus caroliniana*, *Crataegus*, *Styrax decidua.* A few paludial plants are found in the depth of these swamps (*Onoclea*, *Osmunda*, *Woodwardia*, *Peltandra*, *Hymenocallis occidentalis*) and in the openings where pools occur *Saururus cernuus*, *Sabbatia calycina* and *Bidens involucrata.* This swamp formation is also typically represented in Texas for example along the lower Neches and Sabine rivers[1]). It also extends northward into Arkansas, where I have seen it along the valley of the Red River and as far as southeastern Missouri. The relative representation of species varies greatly in different areas. In one place *Nyssa biflora* is dominant, in another *Taxodium distichum* elsewhere *Carya aquatica.* In Mississippi near New Orleans, the species of these swamps, according to HARPER, consist of *Taxodium*, *Sabal Adansonii*, draped with *Tillandsia usneoides*, together with *Salix nigra*, *Acer rubrum*, *Baccharis*, *Zizania*, *Panicum gymnocarpum*, *Cladium effusum* and *Pontederia cordata.* Such differences, however, do not alter the general type of the cypress swamp and bayou forest, which within its own territory retains undisturbed possession.

### 3. Upland Pine Barren and Cedar Swamp-Formations.

*Long Leaf Pine Barren Formation.* The forests of *Pinus palustris* form a narrow strip along the course of the Suwannee River and along the coast to the Appalachicola River. At their southern limit they merge into the oak and hickory uplands of middle Florida. Along the coast they are surrounded by marshes and swamps. The pine lands of western Florida rise slowly above the coastal plain and form a vast expanse of undulating surface. In Alabama where the sandy and gravelly deposits of the latest Tertiary strata prevail *Pinus palustris* forms pure forests with the exception of narrow strips of hardwood, bordering the water courses. On by far the greater part of the sandy, poor and dry soils of Alabama this pine forms pure stands. In some cases there is a rather dense undergrowth of stunted specimens of *Quercus mary-*

1) BRAY, WILLIAM L.: Forest Resources of Texas. Bureau of Forestry Bulletin No. 47. U. S. Department Agriculture 1904: 16.

*landica*, *Q. falcata* (= *Q. digitata*), *obtusiloba*, *coccinea* and species of *Carya*, together with *Cornus florida* and *Oxydendrum arboreum* etc., but more often the undergrowth is entirely lacking or consists of a few widely scattered individuals of the above species. In the latter case the ground cover consists of a mat of grasses and numerous species of the orders Compositae and Leguminosae. Where the soil is more fertile and retentive of moisture the hardwoods form an important part of the forest. Here *Pinus mitis* (= *P. echinata*) and *P. Taeda* make their appearance and sometimes crowd out *Pinus palustris*. The steep northern slopes of higher elevations such as York and Reedy mountains and the Weogufka range are covered with deciduous trees. On the southern slopes a pure forest of *Pinus palustris* extends up to 1000 feet to be replaced at higher elevations by hardwoods. The occurrence of *Rhododendron maximum* and *Kalmia latifolia* as an undergrowth considerably alters the appearance of the forest as on the hills between Finnegotchkee and Weogufka creeks, the former on cool northern exposures and the latter in small clumps on the steep, rocky and dry southern exposures [1]). The coastal plain above the extensive grassy marshes in Mississippi consists of rolling pine lands (7,712,000 acres = 31,302 qkm) almost exclusively covered by the long-leaf pine. West of the Mississippi River, the long-leaf pine is limited to the sands and gravels of the latest Tertiary formations. They are found above the great alluvial plain in Louisiana where towards their northern limit they pass gradually into a mixed growth of deciduous trees and *Pinus mitis*. In the center of this region the pine ridges alternate with tracts of white oak and hickory. Tending toward the Red River the pure forest of *Pinus palustris* is unbroken. In Texas this forest formation extends from the Sabine River west to the Trinity River and from the grassy savannas of the coast region north and are unrivalled elsewhere except perhaps in Louisiana. This forest area is unique in its isolation far to the southwest of the main longleaf pine belt, east of the Mississippi. The Texas portion is shaped like a broad wedge thrust in between *Pinus Taeda* [2]) at the south and *Pinus mitis* at the north and extends southwestward to the Trinity River where the overlapping areas of *Pinus Taeda* and *Pinus mitis* form its western boundary.

The high forest is almost bare of undergrowth and its monotony is frequently unbroken for long distances, no other trees or shrubs appearing among the tall trunks of the pine. On sterile ridges deeply covered with a

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1) REED, FRANKLIN W.: A working plan for forest Lands in central Alabama. U. S. Forest Service Bulletin 68. 1905.

2) Wherever swamps are drained, prairie surface disturbed, or original forest removed there the loblolly pine Pinus Taeda finds congenial conditions for growth, so that four types of loblolly pine forest are recognizable in eastern Texas, viz., loblolly pine in pure groups on wet prairie; loblolly pine in pure stands on fairly, well drained light soil; loblolly pine in mixture with hardwoods. On poorly drained soil or on well drained fertile soils and loblolly pine in pure stands on old fields. ZON, RAPHAEL: Loblolly pine in eastern Texas. U. S. Forest Service Bulletin 64. 1905.

mantle of loose white sands the long leaf pine becomes stunted and is replaced by *Quercus cinerea* and *Catesbaei*, trees below medium size, and among the latter *Vaccinium stamineum*, *V. myrsinites*, *Gaylussacia dumosa*, *Asimina parviflora*, *Ceratiola ericoides* the latter extending to the Mississippi.

The floor of these open pine forests owing to the abundant and evenly distributed rainfall is covered with a carpet of grasses and other herbs, mostly perennials [1]).

*Pine Barren Flat Formation.* The oldest strata of the post-Tertiary beds of loose sands and compact more or less aluminous clays toward the northern limit of the pine barrens of Alabama reach the surface. The higher levels include tracts of badly drained barrens underlaid by the older strata flooded after every heavy rain, droughty during hot and dry weather. On these flat *Pinus caribaea* (= *P. heterophylla* = *P. cubensis*), reaches its northern limit. Excepting *Ilex glabra* scarcely any tree or shrub shades the ground, but herbaceous plants clothe the extremely poor soil, viz., *Andropogon virginicus*, *Anthaenantia rufa*, *Paspalum glabratum*, *Panicum polyanthes*, *Sabbatia gracilis* and *chloroides*, *Helenium brevifolium*, *Rhexia mariana*, *stricta*, and *Cynoctonum sessilifolium*.

Similar flats in Texas are frequently covered with a dense growth of large shrubs and small sized trees consisting of Crataegus crus-galli, C. viridis, C. mollis, C. berberidifolia, Ilex decidua, Ilex caroliniana, Forestiera (Adelia) acuminata, Platanus occidentalis and magnolias. These impenetrable thickets are common.

Sagittaria-Association. In exposed shallow pools in the dry pine barren formation occur Sagittaria Chapmanii, S. cycloptera.

Sarracenia-Association. In many localities the declivities of the table-lands are perpetually wet with water which oozes from the porous silicious strata immediately overlying the impervious clay and the depressions are clothed witb Sphagnum macrophyllum, S. imbricatum var. cristatum, S. recurvum, Lycopodium alopecuroides, Rhynchospora pusilla, R. plumosa, R. rariflora, R. oligantha, Eleocharis acicularis, Calopogon pallidum, Juncus trigonocarpus, Lophiola aurea, Eriocaulon decangulare, Drosera intermedia, Tracyi [2]), Utricularia juncea, U. subulata, Sarracenia purpurea, S. psittacina, Sabbatia macrophylla. The above mentioned pitcher plants (Sarracenia) rest their leaves on the water-soaked peat moss. Sarracenia Drummondii, S. rubra with erect leaves are abundant on the black peaty soil which covers the undulations where the impervious aluminous clays and compacted sand prevail.

*Cypress-White Cedar Swamp Formation.* This formation occupies the damp or wet, more or less sandy banks of the numerous streams of the Gulf coastal plain. *Quercus laurifolia*, *Q. aquatica* (= *Q. nigra*), *Magnolia grandiflora*, *Pinus caribaea* (= *P. heterophylla* = *P. cubensis*), *Taeda*, *mitis* (= *P. echinata*), *Taxodium imbricarium*, *Chamaecyparis thyoides* largely prevail over *Nyssa biflora*, *Acer rubrum* and *Liquidambar styraciflua* (see p. 448). Among the trees of smaller size and shrubs which form a dense undergrowth are

1) TRACY, S. M.: Report upon the forage Plants and forage Resources of the Gulf States Bulletin 15. U. S. Division of Agrostology 1898, p. 12.

2) This plant up to 1905 had been called Drosera filiformis Raf., but Dr. J. M. MACFARLANE has shown it to be distinct and named it D. Tracyi for Prof. TRACY of Biloxi, Miss.

*Cliftonia ligustrina* (= *C. monophylla*), *Cyrilla racemiflora*, *Ilex myrtifolia*, *I. coriacea* (= *I. lucida*), *I. glabra*, *Myrica cerifera*, *M. inodora*, *Kalmia latifolia*, *Illicium floridanum*, *Andromeda* (*Pieris*) *nitida*, *Leucothoë axillaris*, *Oxydendrum arboreum*, *Calycanthus* (*Butneria*) *florida*, *Clethra alnifolia*, *Halesia* (*Mohrodendron*) *diptera*, *Viburnum nudum*, *V. molle*, *Styrax pulverulenta*.

*Upper-Pine Mixed Forest Formation.* This formation consists of a mixed growth of pine and broad-leaved evergreen trees alternating with belts of pure forests of *Pinus palustris*. In Alabama this phytogeographic formation is confined within the limits of the older Tertiary strata. On account of its vegetation it is difficult to define the floral character of this region. Where the rocky ridges are covered by more recent strata, the pine forms magnificent forests. *Cornus florida* and *Quercus Catesbaei* form the scanty undergrowth. The rocky hills where the pine hardly grows are sparingly covered by *Vaccinium stamineum*, *Gaylussacia dumosa*, *Viburnum acerifolium*, *Smilax bona-nox*. The herbaceous plant associations in these pine forests do not differ from those forming the soil cover in the open pine forests of the adjoining lower pine belt. In the eastern extension of this region the loose Ozark sands form the arid surface soil spreading over a large portion of western Florida and southern Georgia.

On the lower flanks of the ridges and on the lower hills of the central pine region, *Pinus mitis* (= *P. echinata*) in Alabama mingles with *Pinus palustris* and with *Castanea pumila*, *Tilia heterophylla*.

As these declivities merge into the narrow valleys with fresher soil more retentive of moisture the following representative trees appear. Pinus glabra, Quercus aquatica, Q. laurifolia, Magnolia grandiflora, M. macrophylla, Fagus americana associated with Styrax grandifolia, Illicium floridanum, Aesculus parviflora, A. pavia, Ilex longipes, Calycanthus florida, Chionanthus virginica. Clematis Catesbyana, C. reticulata, C. crispa may be added as lianes. The terraces of these streams overflowed only in the times of the heaviest freshets are covered with a valuable growth of Quercus Michauxii, Q. falcata (= Q. digitata), Q. texana, Fraxinus americana, Gleditschia triacanthos, Carya alba (= Hicoria ovata).

The hardwood forests of the alluvial bottoms in Texas extending up the valleys (worn inland by erosion) for a distance sometimes of a hundred miles and five miles in width consist of *Quercus Michauxii*, *Q. macrocarpa*, *Q. lyrata*, *Q. alba*, *Q. texana*, *Q. phellos*, *Q. aquatica* (= *Q. nigra*) while as secondary species occur *Fraxinus americana*, *Liquidambar styraciflua*, *Nyssa sylvatica*, *Carya olivaeformis* (= *Hicoria pecan*), *Carya alba* (= *Hicoria ovata*), *Nyssa aquatica*, *Platanus occidentalis*, *Tilia americana*, *Acer saccharinum*, *Ostrya virginiana*, *Carpinus caroliniana*, *Maclura aurantiaca* (= *Toxylon pomiferum*), *Juglans nigra*. On the rich loose bottom soil the timber grows very large and the undergrowth is generally very dense. Certain tracts of this forest in the Red River Valley are occupied by an almost pure growth of *Quercus macrocarpa*. On the lower Trinity, the San Jacinto, *Quercus pagodaefolia* and *Q. alba* are especially abundant. On the Red River, *Populus monilifera* is common, while *Nyssa sylvatica* in places forms a pure forest on the Sulphur

Fork, and the red cedar *Juniperus virginiana*, at the westward turning bend of the Red River and Brazos River Valley.

Creek land[1]) covers the bottoms of valleys in Alabama and is provided with a deep, well-watered soil enriched from the sloping hills. A large number of deciduous trees grow in such situations, among them are Quercus alba, Q. Michauxii, Q. obtusiloba, Q. prinus, Q. tinctoria, three or four species of Carya (Hicoria), Fagus, Liriodendron tulipifera, Fraxinus sp., Liquidambar styraciflua, two or three species of Magnolia, Cornus florida, Oxydendrum arboreum, Acer rubrum, Acer saccharum, Carpinus caroliniana, Tilia americana, Ilex opaca, Ostrya virginiana, and Betula nigra. Pinus Taeda is scattered through this forest with an occasional tree of Pinus mitis. The underbrush is usually dense and consists of various deciduous shrubs and herbs.

### 4. Central Pine Belt- and Central Prairie-Formations.

*Forest Formation.* This belt varies in width from 10 miles to a little over 35 miles in width the soil consisting of sand and pebbles. The deeper sandy loam of this pine belt is occupied by *Pinus palustris* associated with *Quercus obtusifolia*, *Q. falcata*, *Q. tinctoria*, *Q. Catesbaei*, *Carya alba* and *C. porcina* (= *Hicoria ovata* and *glabra*) and where more silicious soils prevail, *Pinus palustris* reigns supreme. *Illicium floridanum*, *Cliftonia ligustrina*, *Persea carolina* occur along the streams with *Sabal Adansonii*, *Yucca aloifolia* and *filamentosa*.

The Central Prairie Territory comprises the plain of Cretaceous rocks which crosses Alabama in a belt from 35 to 45 miles wide, its mean elevation above the Gulf of Mexico exceeding 200 feet.

*Post-oak Prairie Formation.* This phytogeographic formation occupies clayey loams, sands and pebbles which mingle with the soil resulting from the decomposition of the underlying limestone strata. Open xerophilous forests of *Quercus falcata*, *Q. tinctoria*, post oak *Q. obtusiloba* (= *Q. minor*) the last predominant associated with *Carya alba* and *porcina* (= *Hicoria ovata* and *glabra*). Under cover of the brush, the gramineous associations predominate.

This formation is typically represented in Texas where it occupies the sands, gravels and clays of the lignitic belt far into the Rio Grande plain. But isolated from the main belt are other extensive areas of this type of forest, which in general occurs westward to the one hundredth meridian. This is the type of forest which the Atlantic forest assumes when it passes into the arid southwest. Aside from *Pinus mitis*, *Quercus obtusiloba* is the most abundant and universal and after this *Quercus marylandica*, *Q. cinerea*, *Carya porcina* (= *Hicoria glabra*) and *C. myristiciformis*, while a few species of the alluvial bottoms penetrate into the upland forest, viz., *Ulmus americana*, *Quercus alba*, *Q. rubra*, *Liquidambar styraciflua*[2]).

*Prairie Forest Formation.* This occupies the black, calcareous, highly fertile soil rich in humus of the uplands. *Quercus lyrata*, *Q. laurifolia*, *Q. aqua-*

1) REED, FRANKLIN W.: A working plan for forest Lands in central Alabama. U. S. Forest Service Bulletin 68, p. 11 (1905).

2) BRAY, WILLIAM L.: Forest Resources of Texas. Bureau of Forestry Bulletin No. 47: 26. U. S. Department Agriculture.

*tica*, *Liquidambar*, *Fagus*, *Hicoria ovata* and *minima* all draped with *Tillandsia usneoides* are prominent. With the rise of land above the action of occasional overflows are found *Liriodendron*, *Tilia americana*, *Celtis occidentalis*, *Persea borbonia*, together with *Quercus breviloba*, *Carya olivaeformis* (= *Hicoria pecan*) and *C. myristicaeformis*. Trees of smaller size occur here: *Asimina*, *Cercis*, *Rhamnus caroliniana*, *Laurus benzoin* and many lianes (*Vitis aestivalis*, *V. cinerea*, *V. rotundifolia*, *Berchemia*, *Bignonia crucigera*, *Ampelopsis*, *Tecoma*, *Smilax*, 3 spec., *Brunnichia cirrhosa*, *Aristolochia tomentosa*, *Calycocarpum Lyoni*, *Schizandra coccinea*).

*Cedar Hammock Formation* (*Juniperus virginiana*). On the highest swells of the plain where the strata of rotten limestone are overlaid by lighter loams poorer in humus, deep and perfect drainage forests prevail of a mixed tree growth. *Fraxinus americana*, *Quercus laurifolia*, *Q. texana*, *Celtis mississippiensis*, *Ulmus americana*, *Juniperus virginiana*. Originally *Juniperus virginiana* forms about 30 per cent of the timber growth. The Edwards Plateau in Texas is covered with dense growths of this Juniper called cedar brakes. The trees stand thickly and the forest is so dense as to be penetrable only with extreme difficulty. The most extensive of these areas are those of the Colorado River from Austin to the San Saba country.

*Treeless Prairie Formation.* The lower eminences of the plain with the strata of limestone near the surface and destitute of trees are named in Alabama "bald prairies". These bald prairies can be regarded as the true home of the original campestrian flora, which is peculiar to a calcareous soil rich in humus and with a sunny exposure. Many of its types are common to the prevalent associations on the grassy timberless plains of eastern North America.

The following grasses are common: in the open prairie: Paspalum laeve, P. distichum, Panicum flexile, P. autumnale, Andropogon furcatus, Bouteloua curtipendula, Eragrostis capillaris, E. refracta, E. Purshii, Poa compressa, Elymus virginicus. Associated with the grasses are: Hypericum sphaerocarpum, Petalostemon candidus, P. purpureus, Cassia multipinnata, Polygala mariana, Linum sulcatum, Gaura Michauxii, Asclepias obovata, Asclepiodora viridis, Eupatorium altissimum, E. serotinum, Silphium laciniatum, S. scaberrimum, S. trifoliatum, Rudbeckia triloba, Helianthus hirsutus, H. divaricatus, Coreopsis lanceolata, Lepachys pinnata, Polygala Boykinii, Gaillardia pulchella, Monarda citriodora.

The coast prairie of Texas, according to BRAY, is so low and flat that where the rainfall exceeds 35 inches, the vegetation has many aspects of the prairie marsh. Moisture-loving grasses, sedges and wet-soil annuals constitute the vegetation of the coast prairies, whose vegetation is coincident with that of certain prairies that extend through Alabama to Florida and South Carolina previously noted. The grasses are species of the genera Paspalum, Panicum, Andropogon, Eragrostis, probably the same as above noted, together with such wet soil annuals as Sisyrinchium angustifolium, Hymenocallis occidentalis, Ranunculus trachyspermus and muricatus, Baptisia laevicaulis, B. sphaerocarpa, Oenothera sinuata etc.

## D. Arkansas-Louisiana District.

This district floristically speaking possesses many of the plants found along the Gulf coast, but the absence of the longleaf pine, *Pinus palustris*,

and its replacement by the short leaf pine, *Pinus mitis* (= *P. echinata*) is sufficient to characterize it. The line which demarcates the two regions, therefore, is the northern boundary of *Pinus palustris*. Besides it is inland, and physiographically it covers a territory entirely different in character from the coastal plain. It is a district which owes its physiographic condition to the Mississippi River, which in its meanders has swung several times across its flood plain giving rise to freshwater alluvial deposits, or bow lakes, numerous bayous, freshwater swamps and marshy plains. The type of forest and vegetation has been modified accordingly and although many species of the Gulf coast are present yet the character of the association of species rather than the constitution of the primary formation show a considerable modification.

## 1. Lower Alluvial Forest land.

The alluvial bottom land of the Mississippi Valley is covered by mighty forests. In the lowest levels with the surface soil, constantly under water are found the cypress swamps where *Taxodium distichum* is supreme. On slightly elevated ground *Quercus virginiana*, *Q. laurifolia*, *Q. aquatica* draped with *Tillandsia usneoides* occur, and under the shade of the older larger trees a growth of secondary species: *Quercus texana*, *Fraxinus viridis* (= *F. lanceolata*), *Salix nigra*, *Crataegus viridis*, *Ilex verticillata*, *I. decidua*, *Forestiera acuminata*[1]). The trees in the shallow portions of these swamps support certain lianas: *Smilax bona-nox*, *S. pseudo-china*, *Clematis crispa*. Certain of these sloughs are almost exclusively occupied by *Leitneria floridana* a plant found nowhere else except in coastal Florida, its northern extension being due to the swampy character of much of the land along the general course of the Mississippi River in southern Missouri, northern Arkansas as well as further toward the Gulf[2]).

*Cypress Swamp Formation.* The cypress swamps of southeastern Missouri are typically developed about the Saint Francis River. Here in deep swamps occur *Taxodium distichum*, thickets of *Planera aquatica* (in soil never covered with a great depth of water) and the rare and monotypic *Leitneria floridana* with *Polygonum densiflorum*, which seems to be the first in order of succession of those plants which obtain a foothold in the soil and lift themselves out of the water[3]). A large part of the river bottom is covered with *Myriophyllum*, *Ceratophyllum*, *Potamogeton* and *Cabomba* and the consequent filling up of the channel enables *Polygonum densiflorum* and *Zizaniopsis miliacea* to grow. In many quiet places the water is covered with *Azolla caroliniana*, *Lemna*

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1) Mohr, Carl: Die Wälder der Alluvialregion des Mississippi in den Staaten Louisiana, Mississippi und Arkansas. Pharmaceutische Rundschau XIII: 14. 30. Jan. 1895.

2) Bush, B. F.: Notes on a List of Plants collected in southeastern Missouri in 1893. Fifth Report Missouri Botanical Garden 1894: 139—153; Trelease, William: Leitneria floridana do. Sixth Report 1895: 65—90. See also Trelease, Wm.: Garden and Forest X (1897) 376.

3) Coulter, Samuel M.: An ecological Comparison of some typical swamp Areas. 15th Report Missouri Botanical Garden p. 54.

*minor*, *Ricciocarpus natans* and on the drier shore line *Saururus cernuus*, *Sium cicutaefolium*. Outside of these *Cephalanthus occidentalis* abounds. The swollen bases of *Nyssa uniflora* afford a favorable foothold for the epiphytic fern *Polypodium incanum*. The vegetation of the sloughs in the state of Arkansas is essentially similar to the cypress swamps in Missouri and elsewhere in the Mississippi Valley, according to RECORD [1]. In the Wabash Valley the southern cypress *Taxodium distichum*, *Carya* (*Hicoria*) *aquatica*, *Planera aquatica*, *Gleditschia inermis*, all of the south, find their northern home and there the rare swamp cottonwood *Populus heterophylla* grows to its largest size. Beneath these trees grow *Cephalanthus* and *Lindera*. The lizard tail, *Saururus cernuus* is also abundant in low wet spots.

*Pond Formation*. *Nelumbo lutea* occupies the shallow margins of the ponds near which grows *Polygonum amphibium* and in association with these *Pontederia cordata*, *Echinodorus radicans*, *Heteranthera reniformis*, species of *Sagittaria*, *Hibiscus moscheutos*, *H. militaris*. The floating vegetation consists of *Nymphaea*, *Nuphar*, *Cabomba*, *Brasenia* and partly submerged partly floating species. Margining the pond grew *Cephalanthus occidentalis* with its lower branches bearded with black tufts of a species of lichen Ramalina. Behind the buttonbush stood the tall dark wall of the forest.

Nelumbium Association. Parallelling the mighty river between the bayous and rivers are troughs as one of the characteristic features of the topography [2]. They are of various extent depth and shape forming tracts of wet forest swamp or swamps rarely entirely free from water or ponds and lagoons more or less shallow usually open or more or less studded with the knees and mighty trunks of the cypress Taxodium distichum. Nelumbo lutea, Nuphar advena grow in these pools and in open places Nasturtium (Roripa) lacustre, while Hottonia inflata is a characteristic floating plant.

Populus Association. The cottonwood Populus monilifera (= P. deltoides) is found reaching large dimensions especially along the banks of the Mississippi River.

*Hardwood Bottom Formation*. Below the bluff in northern Mississippi, according to Hilgard (Soils: 492) lies the great Mississippi Bottom with its rich soils and varied forest growth. This subdivides into at least three distinct soil and vegetation strips, viz., the sandy frontlands, the backlands, whose soils are partly the product of modern swamp deposits, partly from the disintegration of calcareous clays, and thirdly, the dogwood ridge, a narrow belt of slightly elevated land, mostly above ordinary overflows. In the forests covering the lower lands which slope back to the swamps and lagoons the cow oak, *Quercus Michauxii* is prominent while the overcup oak *Q. lyrata* occurs everywhere in the more or less saturated soil. Here *Liquidambar styraciflua* reaches its greatest size associated with *Carya amara* (= *Hicoria minima*), *Sassafras officinale* (= *S. Sassafras*), *Ulmus americana*, *Carpinus caroliniana*, *Platanus*

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1) RECORD, SAMUEL J.: The Forests of Arkansas. Forest Quarterly V: 296—301. 1907.

2) ED. Some river bank Flowers. Botanical Gazette I: 51; also consult HOUGH EMERSON: The Sunken Lands. Recreation, October 1909 where a description is given of these bayous with good reproductions of native vegetation.

*occidentalis*, *Negundo aceroides*, *Acer rubrum* of enormous size. *Gleditschia triacanthos*, *Quercus aquatica*, *Q. falcata*, *Q. rubra* are equally common [1]). Dense grow hs of cane, *Arundinaria tecta* (Arundinaria Association) forms in many places a large part of the ground cover under the large trees.

In central Arkansas along the Arkansas River and its tributaries this plant formation exists in narrow belts on either side of the creeks and larger streams. At any considerable rise of the streams they are flooded and during the rainy season (in late winter and spring), they often remain under several feet of water for weeks at a time. *Liquidambar* and *Nyssa sylvatica* form here about a fourth of the total stand.

West of the Mississippi River south of the Arkansas River the trees of this forest are *Ulmus crassifolia*, *Fraxinus americana; Quercus Michauxii* and *obtusifolia* forms the post oak associations which extends westward into Texas.

This oak is associated on the drier less sour soils with Quercus alba, Q. falcata, Celtis mississippiensis, while the undergrowth consists of Bumelia lanuginosa, Diospyros virginiana, Crataegus viridis, Planera aquatica, Cornus stricta, C. sericea, Ilex decidua. Lianes are frequent comprising Vitis rotundifolia, V. aestivalis, Ampelopsis cordata, A. arborea, A. quinquefolia, Clematis virginiana, C. crispa and several species of Smilax. Sabal Adansonii grows everywhere in the higher drier ground that border the morasses and swamps. The wet soil of these woods supports Carex eruscorvi, C. stipata var. maxima, C. decomposita, C. intumescens, C. Torreyi, Muhlenbergia mexicana, M. diffusa.

The herbaceous plants of these hardwood bottoms are Dioclea Boykinii, Amorpha fruticosa, Aster diffusus, Solidago (several species), Dianthera humilis, Hygrophila lacustris, Trepocarpus aethusae, Cynoscyadium digitata, Asclepias perennis, Trachelospermum difforme, Gratiola virginiana.

Perhaps the most remarkable aggregation of trees in the north temperate zone is found in the lower Wabash Valley in Illinois where the number of indigenous species south of the mouth of White River is one hundred and seven. Our knowledge of this forest is due to two men Dr. ROBERT RIDGWAY and Dr. JACOB SCHNECK [2]).

The forests of this territory are emphatically of the mixed type as it is rare to find a single species predominating over the others though in particular localities *Quercus alba*, *Acer saccharum*, *Liquidambar styraciflua* may largely prevail. Usually however the 107 species of trees are mixed together indiscriminately the relative abundance of the component species varying with the location, character of soil, geologic formation and other local causes. An area of less than one square mile showed the following seventy five species of trees:

Asimina triloba L.
Acer saccharum Marsh. (= A. saccharinum Wang.).
» rubrum L.
Acer dasycarpum Ehrh. (= A. saccharinum L.).
Gleditschia triacanthos L.

1) SARGENT, CHARLES S.: Report on the Forests of North America. 10th Census 1884: 535.

2) RIDGWAY, ROBERT: Notes on the native Trees of the lower Wabash and White River Valleys in Illinois and Indiana. Proceedings U. S. National Museum 1882: 49—88; Notes on the Vegetation of the lower Wabash Valley. American Naturalist VI: 658, 724: VII: 154; Editorial: The Forests of the Wabash Valley. Garden and Forest VIII (1895): 101; SCHNECK, J.: Catalogue of the Flora of the Wabash Valley. Cox's Geological Survey of Illinois 1875: 504—579.

Gymnocladus canadensis Lam. (= G. dioicus L.).
Cercis canadensis L.
Prunus virginiana L.
» serotina Ehrh.
Pirus (Malus) coronaria L.
» » angustifolia Ait.
Crataegus crus-galli L.
» coccinea L.
» subvillosa T. & G. (= C. mollis T. & G.).
Liquidambar styraciflua L.
Cornus (Cynoxylon) florida L.
Nyssa sylvatica Marsh. (= N. multiflora Wang.).
Juglans nigra L.
» cinerea L.
Carya amara Nutt. (= Hicoria minima Marsh.).
» porcina Nutt. (= H. glabra Mill.).
» olivaeformis Nutt. (= H. pecan Marsh.).
» alba Nutt. (= H. ovata Mill.).
» sulcata Nutt. (= H. laciniosa Michx. f.).
» microcarpa Nutt. (= H. odorata Marsh.).
» tomentosa Nutt. (= H. alba L.).
Quercus alba L.
» bicolor Willd. (= Q. platanoides Lam.).
» Muhlenbergii Engelm. (= Q. acuminata Michx.).
» coccinea Muench.
» Michauxii Nutt.
» imbricaria Michx.
» palustris Muench.
» rubra L.
» tinctoria Bartr. (= Q. velutina Lam.).
» aquatica Walt. (= Q. nigra L.).
» falcata Michx. (= Q. digitata Marsh.).
Quercus stellata Wang. (= Q. minor Marsh.).
» lyrata Walt.
Tilia americana L.
» heterophylla Vent.
Aesculus glabra Willd.
Gleditschia monosperma Walt. (= G. aquatica Marsh.).
Amelanchier canadensis L.
Fraxinus viridis Michx. f. (= F. lanceolata Borkh.).
» sambucifolia Lam. (= F. nigra Marsh.).
» americana L.
» quadrangulata Michx.
» pubescens Lam. (= F. pennsylvanica Marsh.).
Diospyros virginiana L.
Sassafras officinale Nees et Eberm. (= S. variifolium Salisb.)
Ulmus americana L.
» fulva Michx. (= U. pubescens [Walt.).
» alata Michx.
Celtis occidentalis L.
Morus rubra L.
Platanus occidentalis L.
Negundo aceroides Moench. (= Acer negundo L.).
Liriodendron tulipifera L.
Rhus typhina L. (= R. hirta L.).
Betula nigra L.
» lenta L.
Salix lucida Muhl.
» nigra Marsh.
Populus monilifera Ait. (= P. deltoides [Marsh.).
» heterophylla L.
» tremuloides Michx.
Carpinus caroliniana Walt.
Viburnum prunifolium L.
Catalpa speciosa Warder.
Celtis mississippiensis Bosc.
Ostrya virginiana Mill.
Fagus americana Sweet.
Taxodium distichum L.

The entire absence of coniferous trees except in special and usually very restricted localities is noticeable. The trees which usually attain the largest size are *Platanus occidentalis*, *Liriodendron tulipifera*, *Carya olivaeformis* (= *Hicoria pecan*), *Carya alba* (= *Hicoria ovata*), *Quercus macrocarpa*, *Q. coccinea*, *Fraxinus americana*, *Taxodium distichum*, *Liquidambar styraciflua*, *Juglans nigra*, *Ulmus americana*, *Gleditschia triacanthos*, *Populus monilifera*, *Fagus americana*, *Quercus alba*. All of these exceed one hundred and fifty feet in height and are in one sense dominant.

As an undergrowth occur Zanthoxylum americanum, Ptelea trifoliata, Euonymus atropurpureus, Hydrangea arborescens, Hamamelis virginiana, Ilex decidua, Forestiera acuminata, Lindera benzoin, Alnus serrulata, Aralia spinosa, Ilex verticillata, Amorpha fruticosa, Asimina triloba, Rhus typhina (= R. hirta), R. glabra, R. venenata (= R. vernix), Cercis canadensis, Prunus americana, P. virginiana, Crataegus coccinea, C. tomentosa, C. crus-galli, Pirus (Malus) coronaria, Amelanchier canadensis, Cornus florida, C. alternifolia, Viburnum lentago, V. prunifolium, Fraxinus viridis, Ostrya virginiana, Carpinus caroliniana, Cephalanthus occidentalis (in the bottom lands).

In the primeval forest the river flowed between walls of forest which stood up to the very banks with a dense fringe of willows. Salix lucida, S. nigra at the water's edge overrun by luxuriant masses of wild grape or other vines falling down in festoons. Such are Ampelopsis (Parthenocissus) quinquefolia, Vitis cordifolia, Tecoma radicans, Rhus radicans, Wistaria frutescens, Bignonia capreolata (= B. crucigera) which climb the trees to great heights and with massive climbing lianous stems. Smaller woody vines are Cocculus carolinus, Menispermum canadense, Celastrus scandens, Smilax rotundifolia, S. glauca, S. Walteri, S. lanceolata, while the following herbaceous vines should also be included as they trail over the ground or run up the undergrowth of shrubs: Clematis Pitcheri (= C. Simsii), C. viorna, C. virginiana, Passiflora lutea, Ipomoea (Quamoclit) coccinea, Convolvulus (Calystegia) sepium, Convolvulus (C) spithamea, Echinocystis lobata, Humulus lupulus, Dioscorea villosa, Smilax herbacea. Very often the smaller vines are twined about the larger.

Viewed from a high bluff this forest presents the appearence of a compact, level sea of green apparently almost endless, but bounded by a line of wooded bluffs three to seven miles back from the Ohio River. The general level is broken by occasional giant trees which rear their massive tops one hundred and eighty feet above the ground; the approximate height of the other trees being about one hundred and thirty feet. The size of the trunks of some of the trees of the forest is hardly less remarkable than their height. A sycamore (*Platanus occidentalis*) girded thirty-three and a third feet; *Liriodendron tulipifera*, twenty-five feet; *Quercus alba*, twenty two feet; *Quercus tinctoria* (= *Q. velutina*), twenty feet; *Quercus texana* twenty feet.

## 2. Upland Pine Flat and Forest Land.

*Upland Deciduous Forest Formation.* Along the elevated ridges fronting the streams *Quercus alba*, *Q. phellos*, *Juglans nigra*, *Carya alba* and *C. tomentosa* occur in great numbers together with *Liriodendron tulipifera*, *Sassafras*, *Morus rubra*, *Quercus falcata*, *Liquidambar*, *Nyssa sylvatica*. The undergrowth consists of *Crataegus viridis*, *C. crus-galli*, *Lindera benzoin*, etc.

This forest in Texas reaches its western limit. Here along the creek bottoms *Fagus americana* is found associated with *Quercus aquatica*, *Acer sac-*

*charum*, *rubrum*, *A. dasycarpum*, *Fraxinus americana*, *Ulmus*, *Ostrya virginiana*, *Carpinus*, *Tilia*, *Cornus florida*, *Hamamelis*, *Negundo*, *Prunus serotina*. The botanist might fancy himself in a northern forest but the presence of *Magnolia grandiflora* (= *M. foetida*), *M. glauca* (= *M. virginiana*), *Persea carolinensis*, *Ulmus alata*, *Planera aquatica*, *Castanea pumila*, *Ilex cassine* convinces him that he is in the woods of the Arkansas-Louisiana District [1].

*Pine Flat Formation.* On the low almost perfectly flat lands of Arkansas-Louisiana, Mississippi and Texas the soils are of the same general character, but contain a large amount of clay and are, therefore, moist. Over considerable areas on these flats, and especially in the open spaces, there is a dense and often quite high growth of grasses, ferns and ericaceous plants. *Pinus Taeda* is the most common tree on the pine flats, and usually dominates. *Pinus mitis* (= *P. echinata*), is also well represented associated with *Quercus alba*, *Q. obtusiloba*, *Q. falcata*, *Q. tinctoria* while hickory is very scarce [2]. In this forest the pines stand high above the crown of the hardwoods, the latter forming a kind of undergrowth; but instead of occurring by single trees, the pines of these flats have a decided tendency to grow in large groups, or forming open groups and clumps are the oaks, gums and other hardwoods. In Texas the sandy ridges are covered normally with a pure growth of *Pinus Taeda*, while the flats are covered with a jungle of hardwood (oaks of several species) with some loblolly pine, a dense undergrowth of small trees, palmetto thickets and climbing vines looping over the branches of the trees. The forests on the pine flats are the densest in Texas with a very thick undergrowth of shrubs and small shade-loving trees.

*Pine Ridge Formation.* The pine ridge forests occur on all the gently rolling or hilly portions of the country. The soils are deep, dry and rather compact loamy sands, usually with a slight admixture of clay and with an occasional bed of gravel or pebble. *Pinus mitis* (= *P. echinata*) forms a little more than fifty per cent of the total stand and is more than twice as abundant as *Pinus Taeda*. These pines tower high above the hardwoods, forming a second story above *Quercus alba*, *Q. obtusiloba*, *Liquidambar styraciflua*, *Q. falcata*, *Q. tinctoria*. The undergrowth consists of species of *Vaccinium*, *Kalmia latifolia*, *Persea pubescens* and species of *Smilax* are found both in large and small groups and scattered openly and irregularly, while over large areas it is entirely absent, leaving the ground clear and bare under the mature trees. This type of shortleaf pine reaches by far its best development in the United States in northwestern Louisiana, southern Arkansas and northeastern Texas forming forests scarcely surpassed in their timber wealth. Its general distribution west of the Mississippi River is the country

1) E. N. P. In the Woods of eastern Texas. Garden and Forest V: 399. Aug. 24, 1892; see also BRAY, W. L.: Texas Forests. The Forester VII: 31 June 1901.

2) OLMSTED, FREDERICK E.: A working plan for forest Lands near Pine Bluff, Arkansas. Bureau of Forestry Bulletin No. 32: 22. U. S. Department Agriculture 1902.

north of the longleaf pine belt where it is most abundant and reaches its greatest perfection. In Arkansas in the hilly country *Pinus mitis* forms a large part of the tree covering of the silicious rocky soil and frequently extensive forests on the wide table-lands. In northeastern Texas the pine forests are called pineries" forming a compact growth over many hundreds of square miles.

In Alabama and Mississippi *P. mitis* is rarely seen in the lower part of the coast-pine belt (see ante § C, p. 451), but forms a more or less conspicuous part of the forest covering of the uplands in the central and upper territories (20—30 per cent) and sometimes predominates to such an extent over the usually dominant hardwoods as to impart to the woodlands the somber aspect of a pure pine forest. Dense groves of this tree cover the shallow depressions deficient in drainage which are particularly frequent on the Warrior table land.

## 3. Piedmont-Appalachian-Ozark Plateau-Mountain Region.

This phytogeographic region occupies territorially the Piedmont Plateau, the Appalachian mountains and valleys, the Alleghanian Plateau west of the mountains and a portion of the great central plain extended west to the Ozark-Plateau and mountains in Missouri. Geographically it extends from central New Jersey and the Catskills south to northern Alabama.

This vast area is generally speaking the home of the broadleaf species of trees. The entire region sloping toward the Atlantic Ocean, the Appalachian mountains and plateaus and spreading far westward to the Mississippi River, and beyond, is characterized by the presence of broad-leaf trees. Not that the conifers are here entirely absent, for several of these including the white pine, *Pinus strobus*, follow the mountain ranges and scatter throughout the hills and plains, but their number is small in the proportion of the whole. The higher mountains are characterized by such trees as *Picea nigra* (= *P. mariana*), *Sorbus americana*, which have their main center in the north; but the deciduous-leaved trees cover valleys and plains, and ascend in serried ranks the mountain sides, pass from one valley to another through the mountain passes and cross whole mountain ranges by surmounting and covering the lower crests and mountain tops.

Variety is one of the marked characteristics of the eastern woods. As several hundred different kinds of trees enter into their composition under every form and modification of circumstance and association, we find in these forests an endless novelty. Three districts are recognizable, viz., the Piedmont District; the Appalachian District; the Alleghanian-Ozark District. These will be treated of in order.

### A. Piedmont District.

This is coincident with the Piedmont Plateau. The common boundary of the coastal plain and the Piedmont Plateau is usually well defined though sometimes inconspicuous. Between the Hudson River and the Tuscaloosa (or Black Warrior) River the streams cross it in cascades, or rapids, and the

boundary is thus known industrially and geographically as the "fall line". This boundary is one of the most strongly marked physiographic and cultural lines on the surface of the globe, so writes Professor W. J. McGee [1]). On the one hand lie the crystalline rocks, while on the other, there is a series of incoherent and undisturbed deposits of clay, sand and gravel, through which the waters move sluggishly in broad tidal estuaries. The pioneer settlers ascended the tidal channels to the falls of the rivers, where they found sometimes within a mile, clear, fresh water, the game of the hills and woodlands and the fish and fowl of the estuaries, as well, as abundant water power. Here are found such cities as Philadelphia, Baltimore, Washington, Richmond, Raleigh, Columbia, Macon, Montgomery in Alabama.

There is also a marked delimitation of the floras of the coastal plain and the Piedmont Plateau. The forests of the former are mainly coniferous, of the latter, composed of broad-leafed trees with the corresponding undergrowth of shrubby and herbaceous species.

In New Jersey along the front of the Piedmont Plateau, which ends at the Hudson River, crossing the Delaware River at Trenton, where rapids occur, there is a transition belt where the coniferous forests of the coastal plain blend with the deciduous forests of the Piedmont Plateau, producing a constant state of strain, or tension. The elements in the deciduous flora are always ready to seize upon any advantage which will give them a foothold further south, while the elements in the coniferous flora are always ready for an advance in the opposite direction [2]).

The Piedmont Plateau in New Jersey [3]) is characterized by the deciduous tree formation composed of Quercus rubra, Q. coccinea, Q. alba, Q. tinctoria (= Q. velutina), Carya alba (= Hicoria ovata), Carya porcina (= Hicoria glabra), Carya tomentosa (= Hicoria alba), Ulmus americana, Fraxinus americana, Fagus americana, (= F. ferruginea), Castanea dentata (= C. americana), Liriodendron tulipifera, Carpinus caroliniana, Platanus occidentalis, Acer rubrum, Cornus florida, with occasional groups of Juniperus virginiana and Pinus strobus. Liquidambar styraciflua, Sassafras officinale and Populus tremuloides also occur in this forest, but are also abundant in the coniferous (southern) belt. — West Jersey from Trenton southward, west and southwest of the pine barrens, is characterized by a far greater variety of trees than the pine barrens. The most plentiful species, not found in the latter region, are Pinus inops (= P. virginiana), Juniperus virginiana, Quercus phellos, Q. falcata (= Q. digitata), Q. bicolor (= Q. platanoides), Q. coccinea, Castanea dentata, Fagus americana, Betula nigra, Ulmus americana, Carya tomentosa (= Hicoria alba), C. porcina (= H. glabra), C. amara (= H. minima), Carpinus caroliniana, Liriodendron tulipifera, Platanus occidentalis, Diospyros virginiana, Cornus florida, Liquidambar styraciflua, Prunus serotina, Ilex opaca.

A striking fact first emphasized by Witmer Stone is that the narrow Atlantic coast strip between the pine barrens and the salt marshes has much the same flora as the lower Delaware Valley, though many of the trees are absent. The Piedmont Plateau is not typically developed, however, until the Delaware River is crossed at Trenton, and southeastern Pennsylvania is entered.

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1) Mc Gee, W. J.: The Lafayette Formation. Twelfth Annual Report U. S. Geological Survey 1890—1891. Part I: 356—357.

2) Hollick, Arthur: The Relation between Forestry an Geology in New Jersey. American Naturalist XXXIII: 1—14; 109—116. 1899.

3) Harshberger, John W.: The Vegetation of the Navesink Highlands Torreya Jan. 1910.

The flora of this section of country may be considered to be typic of the northern extension of the Piedmont Plateau.

## a) Northern Area.

Southeastern Pennsylvania is a region of hills, of valleys, of meadows and of rocky ravines sloping down in general from the Laurentide hills to the Delaware River. It represents an original table-land whose general elevation was about 500 feet above tide-level. Originally the surface, hills, as well, as river-plain above the fresh water marshes, which line the Delaware River, was covered by a dense forest of trees. Since the settlement of the country, the most desirable land has been under cultivation, with many flourishing manufacturing towns.

Botanically considered, the following ecologic plant formations and associations may be distinguished, and these are determined approximately by the character of the areas above mentioned [1].

### 1. Formations of the Estuaries, Ponds and Marshes.

*Aquatic Formation.* The river and creeks of the region, especially in their lower courses, have smooth stretches of water in which grow a number of aquatic species. These species in the tidal estuaries are usually of the larger sort and are well adapted to grow in water where there is a change of level between high and low tide of about three feet. In many of the streams, the tidal flow is of considerable strength and the current established, therefore, influences the distribution of the vegetation to a marked extent. Where the flow is less strong and swift, there the material in the form of mud and silt is deposited and upon this alluvial material aquatic plants take root and gradually raise the level of these areas by catching and holding fresh deposits of silt. The result is a tidal marsh intersected by numerous meandering channels through which the tidal water ebbs and flows.

*Vallisneria spiralis* forms a pure association of such extent, as seriously to interfere with the navigation of some of the streams (Vallisneria Association). In some of the smaller creeks and in ponds formed in artificial depressions, *Elodea canadensis* abounds. The spatterdock, *Nuphar advenum* is probably the commonest aquatic plant that grows in the tidal portions of the streams of southeast Pennsylvania. It covers acres of mud ground and stretches as a pure association for miles along the Delaware and Schuylkill rivers (Nuphar Association). Associated with it in shallow water the pickerelweed, *Pontederia cordata* abounds, forming in places pure associations. This interesting plant with trimorphic flowers is most abundant on the New Jersey side of the Delaware River (Pontederia Association). The duckweeds are found in the ditches and ponds of the region. This is true especially of the

1) HARSHBERGER, JOHN W.: A phyto-geographic Sketch of extreme southeastern Pennsylvania. Bulletin Torrey Botanical Club XXXI: 125–159. March 1904.

district in South Philadelphia known as the Neck. The agricultural land, kept in a high state of fertility by the application of city manurial waste, is intersected by numerous ditches where abound *Spirodela polyrhiza*, *Lemna minor*, *Wolffia brasiliensis* and *W. columbiana* (Lemna Association). *Orontium aquaticum*, the goldenclub, is also a plant that forms in places ecologic groups (Orontium Association). The water-chinquapin. *Nelumbo lutea*, twenty five years ago, existed in the region of the "Neck". With the spread of the city southward, the plant was destroyed.

Pond Formation. There are no ponds or lakes of any size natural to southeastern Pennsylvania; all that now exist are artificial. Some of them occupy depressions from which clay has been taken for bricks; others occupy the bottom of rock quarries, while still others have been formed by the damming of streams. The only natural ponds are of small size and are rather pools formed in a depression near some perennial spring. The ecologist finds in such natural pools, or along their edges, a collection of species that seem to give character to them, such as Chrysosplenium americanum (Chrysosplenium Association), Veronica americana, Elodea canadensis, Typha latifolia, Acorus Calamus, Iris versicolor, Myriophyllum verticillatum, Spirodela polyrhiza, Cardamine rhomboidea (= C. bulbosa), C. rotundifolia, Caltha palustris, Myosotis palustris, Nasturtium palustre, Nasturtium officinale (Nasturtium Association), Ludwigia (Isnardia) palustris and various algae, viz., Spirogyra, Hydrodictyon, Conferva, Nitella, Oedogonium, Volvox, Euglena and Mesocarpus.

*Tidal-marsh Formation.* The tidal marshes have been formed by a variety of contributing forces. Material brought down by the rivers has been sorted and distributed over the tidal areas by the tides and currents of the streams that meet here. The location of these deposits and their superficial extent has depended upon the character, force and direction of the currents.

The banks of the streams influenced by tidal action are lined by thickets composed of *Platanus occidentalis*, *Gleditschia triacanthos*, *Alnus serrulata*, *Acer rubrum*, *Salix alba*, *Liquidambar*, *Fraxinus*, *Sambucus*, *Cephalanthus*, *Rosa lucida*, *Ampelopsis*, and *Rubus nigrobaccus*.

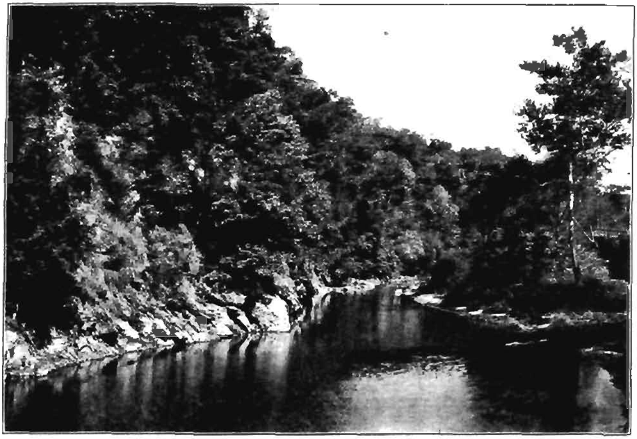
The herbaceous plants are in this rich alluvial soil Thalictrum polygamum, Heracleum lanatum, Agrimonia parviflora, Allium vineale, Ambrosia trifida, Impatiens fulva. In mud near the bank, associations of rose mallow, Hibiscus moscheutos, occur, with occasional patches of the sensitive fern, Onoclea sensibilis. Along the edges of the stream banks in the shallow water grow Jussiaea repens, Calamintha clinopodium, Sagittaria variabilis, Cicuta maculata, Ludwigia alternifolia, Stachys palustris and Asclepias incarnata. In the deeper water, fringing the shore of the creeks, strips of wild rice, Zizania aquatica (Zizania Association) and of Nuphar (Nymphaea) advenum (Nuphar Association) are found.

The tidal marshes of the rivers Delaware and Schuylkill are extensive and may be in places one half a mile wide. Several well marked zonal areas of marsh vegetation are noticeable in making an ecologic survey. Some of the marshes have been diked. Others at high tide are flooded with water, and yet the ecologist can distinguish relative depths of water by the character of the vegetation alone. If one begins with the open channels of the creeks and ditches that intersect the marshes, the following zonal areas can be distinguished. In the deeper water along the channel, the reed-grass, *Zizania aquatica* (Zizania Association) forms the outer fringe of vegetation and where

it does not occur, *(Nuphar advenum)* replaces it and forms a pure growth (Nuphar Association). In July, two colors of reed-grass are noticeable: a dark green mature form in deep water and a light green immature growth of reed-grass inside of the dark green area. In the shallower water behind the reed-grass and spatterdock, several associations of plants are seen. One area is characterized by the commingling of *Sagittaria variabilis*, *Impatiens fulva*, *Ambrosia trifida*, *Nuphar advenum*, with an occasional association of *Hibiscus moscheutos*. In other areas *Impatiens fulva*, *Rudbeckia laciniata* and *Sagittaria variabilis* occur, and on drier soil *Thalictrum polygamum* and *Heracleum lanatum*. *Typha latifolia* forms a pure association (Typha Association) surrounded by *Ambrosia* and *Sagittaria;* in other areas this forms pure associations and in still other situation it is mixed with *Cicuta maculata* (Sagittaria-Cicuta Association). *Cephalanthus occidentalis* always occurs in the drier soil of the tidal marshes and in a number of places with it grow *Cornus sericea*. Alluvial islands occur in the channels of the streams, These are at first covered by the spatterdock, and as the soil becomes drier through the building action of these plants, the spatterdock is replaced by other plants until the island becomes dry enough to support tree vegetation. The marshes have been drained in many cases sufficiently to raise marsh-grass for hay. The ditches of such converted marshes afford many interesting plants of the Lemna-Association (vide p. 463), *Pontederia*, *Hibiscus*, *Asclepias incarnata*, Typha — Sagittaria — Zizania — Association. Outside of these associations and growing in the deeper water along the banks of the Delaware River is an association of *Scirpus lacustris* (Scirpus Association). The between-tide, mud-inhabiting plants along the Delaware River shore are Micranthemum Nuttallii (= M. micranthemoides), Isoëtes riparia (on gravelly beaches), Tillaea simplex (= T. aquatica), Limosella aquatica, Eriocaulon (Dupatya) flavidulum, Sagittaria subulata and Elatine americana. Isoëtes-Limosella Association.

## Swamp-plant Formation.

The swamps of the region under consideration are of three kinds, as determined by their origin: (1) Swamps that owe their origin to a stream flowing over a low, flat area of country; (2) swamps due to underground springs; (3) swamps due to the collection of the drainage water of an area into a natural basin-shaped depression. True sphagnum bogs are not represented in southeastern Pennsylvania. This does not exclude sphagnum mosses from the category of swamp plants, but bogs which owe their character to them are absent, and peaty deposits such as one finds associated with the sphagnum are entirely wanting. The swamp plants characteristic of the region fall naturally into several ecologic associations. Thus, we have the Symplocarpus-Association, consisting of *Symplocarpus (Spathyema) foetida*, *Osmunda regalis*, *O. Claytoniana*, *O. cinnamomea*, *Cardamine rhomboidea* and *Onoclea sensibilis*. The Iris-, Typha- and Acorus-Associations are clearly de-



a. Wissahickon Creek

Fairmount Park, Philadelphia (Piedmont Plateau District), Deciduous Forest Formation.

b. Hemlocks, Tsuga canadensis (L.)

in pure formation above Stony Creek, near Shenandoah City, Penna. (Appalachian District). Coniferous Forest Formation (Tsuga Facies).

marcated. *Heracleum lanatum* forms in swampy places a pure growth, as do also *Veratrum viride* and *Eupatorium purpureum*. *Heliopsis laevis*, *Rudbeckia laciniata*, *Commelina virginica*, *Polygonum sagittatum*, *Mentha spicata* and *Vernonia Noveboracensis* are usually together in alluvial bottom lands at the mouths of streams where the soil is wet (Heliopsis-Rudbeckia-Association).

## 2. Forest formations.

*Deciduous-forest Formation*. Originally the forest covered most of the surface of southeast Pennsylvania. In some places, notably on the Wissahickon Creek within the confines of Fairmount Park and in areas on Crum Creek, the primeval forest still remains [1]. A study of such preserves shows the character of the original forest. The dominant and secondary trees grow on precipitous rocks, on declivitous hillsides, on the plateau surfaces left as a remnant of a former peneplain, on the creek bottoms of the region, where the trees reach their largest size, and on the Delaware River plain down to where the forest formation merges with the river marsh plant formation. All the areas occupied by the cultivated-plant formations recognized were covered by the original forest[2]. The original forest was a mesophytic one. It probably passed through various vicissitudes dependent upon the topographic changes, so that the xerophytic forest of the hillside was gradually replaced by a mesophytic forest. The tendency has been in the entire region to the culmination of the forest in the mesophytic type. The forest, of great original density, may be looked upon as the northeastern extension of the forest found developed in its highest character in the region drained by the Tennessee River and its tributaries and by streams arising in the southern Alleghany Mountains and flowing eastward into the Atlantic. Arbitrarily, a line drawn from a point where the Ohio joins the Mississippi River, east to the Cumberland Mountains and thence along the Alleghany Mountains to the west branch of the Susquehanna River in Pennsylvania, then to the Blue Ridge and along it to the Schuylkill River, following the hills on the south side of the Great Valley to the Delaware River, represents the northern limit during glacial times of the forest which during the Miocene period extend north into the Arctic regions. The northeastern extension of the forest of glacial times was much poorer in species than the mixed deciduous forest farther south. This was probably due to the killing of the less hardy species by the glacial cold. Only those species remained in the area mentioned that were hardy. These hardy species,

1) Fairmount Park, Philadelphia possesses many fine pieces of woodland, where the original forest conditions may be studied. OGLESBY PAUL, landscape gardener of the park, has enumerated in a brochure of 52 pages, the principal trees and estimated their numerical abundance. The list comprises as the most abundant trees of the Park the following: Castanea, Liriodendron, Fagus, Quercus alba, Q. tinctoria, Q. Prinus, Fraxinus americana, Acer rubrum and Cornus florida as a secondary species. — See plate XIa.

2) TROTTER, SPENCER: The Atlantic Forest Region of North America. The Popular Science Monthly LXXV: 370—392. Oct. 1909.

therefore, represent the main constituent species of the present-day forest with the possible introduction of a few additional species that migrated north from the denser forest that clothed the valleys and slopes of the southern Alleghany Mountains.

The **dominant trees** of the forest that covered and still covers in patches southeastern Pennsylvania parts of Delaware[1]) is composed of the following species: tulip-poplar, Liriodendron tulipifera; chestnut, Castanea dentata (= Castanea sativa var americana); black walnut, Juglans nigra; red oak, Quercus rubra; white oak, Q. alba; scarlet oak, Q. coccinea; chestnut oak, Q. Prinus; Spanish oak, Q. falcata (= Q. digitata); beech, Fagus americana (= F. ferruginea); Carya alba (= Hicoria ovata); hackberry, Celtis occidentalis; butternut, Juglans cinerea; sweet gum, Liquidambar styraciflua; persimmon, Diospyros virginiana; white elm, Ulmus americana; white ash, Fraxinus americana; wild red cherry, Prunus pennsylvanica; pignut, Carya porcina (= Hicoria glabra); silver maple, Acer saccharum; red maple, Acer rubrum; buttonwood, Platanus occidentalis; small-fruited hickory, Carya microcarpa (= Hicoria microcarpa) and ironwood, Ostrya virginiana. These trees are found in great variety of soils, but reach their greatest size on the alluvial soils of the creek and river bottoms. Thus the black-walnut, tulip-poplar, white elm, button-wood, red maple and silver maple reach their best development on such soils. The white oak, white ash, chestnut, etc. seem to grow equally well in the drier upland soils. The red cedar, *Juniperus virginiana, on the other hand, seems to be confined to barren places and to* rocky outcrops, while the trees that grow along the banks of the streams within the region comprise the red maple, *Acer rubrum*, the hornbeam, *Carpinus caroliniana; swamp oak*, Quercus palustris; buttonwood, Platanus occidentalis; box-elder, Negundo aceroides (= Acer negundo); beech, Fagus americana; Sassafras officinale and several birches and willows. — The forest in the neighborhood of Washington, DC.[2]) is essentially similar; the dominant trees are: Quercus alba, Q. Prinus, Q. coccinea, Q. palustris, Q. falcata, Carya tomentosa (= Hicoria alba), Liriodendron tulipifera. Among other common trees here are Castanea, Fagus, Acer rubrum, Platanus occidentalis, Betula nigra (along rivers), Ulmus americana, Nyssa multiflora, Liquidambar styraciflua with admixture in groves or singly of Pinus inops, P. rigida, P. mitis.

The trees form a dense canopy, and shade the forest floor, so that the secondary species, shrubs, sapling trees and herbs, must be tolerant of such dense shade. The dominant trees reached their great size in the primeval forest, for some are left which attest this. Thus are found white oaks six to eight feet in diameter, buttonwood trees six feet across, white pine five feet in diameter, beeches four feet, black walnut trees four to five feet, tulip-poplars six feet, sassafras trees two and a half.

The **secondary species**, tolerant of the shade, are the dog-wood, Cornus (Cynoxlon) *florida; red mulberry, Morus rubra; service berry, Amelanchier canadensis;* bladdernut, Staphylea trifolia; Judas-tree, Cercis canadensis; hazel, Corylus americana; witch-hazel, Hamamelis virginiana *and striped maple, Acer pennsylvanicum, while as shrubs occur smooth alder*, Alnus serrulata (= A. rugosa); spice-bush, Lindera Benzoin; dockmackie, Viburnum acerifolium; arrowwood, Viburnum dentatum; stagbush, Viburnum prunifolium; strawberry bush, Euonymus americanus, wahoo, Euonymus atropurpureus, and pinxter flower, Rhododendron nudiflorum (= Azalea nudiflora);

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1) STERRETT, W. D.: Report on Forest Conditions in Delaware. Bulletin 82, Delaware College Agricultural Experiment Station. December 1908, pages 1—58 with map and 10 figures.

2) WARD, LESTER F.: Guide to the Flora of Washington and Vicinity. Bulletin of the United States National Museum. No. 26. 1881.

Sambucus canadensis, the elder, also occurs in the region and at present is found usually in open places with alluvial soil forming thickets of some denseness. The laurel Kalmia latifolia, high-bush huckleberry, Vaccinium stamineum are found in the drier soils throughout the region. The laurel Kalmia latifolia, high-bush huckleberry, Vaccinium stamineum are found in the drier soils. The smaller trees in this formation at Washington, D. C. are: Cornus florida, Cercis canadensis, Hamamelis virginiana, Sassafras officinale, Castanea pumila, Juniperus virginiana, while as shrubs are: Cornus sericea, C. alternifolia, Viburnum acerifolium, V. dentatum, V. nudum, Gaylussacia resinosa, Vaccinium stamineum, V. vacillans, V. corymbosum, Leucothoë racemosa, Andromeda mariana, Kalmia latifolia, Rhododendron (Azalea) nudiflorum, Lindera Benzoin.

The lianes which grow upon the dominant and secondary forest trees are several grape vines, Vitis cordifolia, V. labrusca, V. aestivalis, V. riparia (= V. vulpina); Virginia creeper, Ampelopsis quinquefolia; poison ivy, Rhus radicans and several species of the genus Smilax. The

Fig. 26. *Vitis aestivalis* Michx., a liane at Granogue Station near Wilmington, Delaware. Stem 5 feet 9 inches (1.752 m) in circumference 1 foot (30.4 cm) from ground. Photograph by J. T. Pennypacker. Deciduous Forest Formation. Piedmont District.

climbing bittersweet, Celastrus scandens, moonseed, Menispermum canadense, Sicyos angulatus, wild-yam, Dioscorea villosa, and wild balsam apple, Echinocystis (Micrampelis) lobata are climbing plants found along the course of the streams.

The vines of the neighborhood of Washington, DC. are Ampelopsis quinquefolia, Rhus toxicodendron, Tecoma radicans, Vitis labrusca, V. aestivalis (see Fig. 26), V. cordifolia, V. riparia.

A peculiar type of this mixed deciduous forest is found on the serpentine rock formations of the region under consideration[1]). The botanist can identify the serpentine areas, by the vegetation alone, for the species which

1) HARSHBERGER, JOHN W.: The Flora of the serpentine Barrens of southeast Pennsylvania. Science new ser. XVIII: 339—343.

are character-plants, although occurring elsewhere in the region, are here grouped together in such a manner and in such number, as to sharply delimit these areas from the surrounding country. The dominant trees on the serpentine barrens are *Quercus alba*, *Q. stellata*, *Q. marylandica*, *Q. rubra*, *Acer rubrum*, *Liriodendron*, *Nyssa sylvatica*, *Juniperus virginiana*, *Castanea*, *Fagus* and *Prunus serotina*.

The herbaceous plants of the forest floor are found in pure association, or they occur sparingly distributed along with other herbs that form together a mixed vegetation. The habitats of the different herbaceous associations are controlled by photic and edaphic conditions. Thus in the deep shade of the dominant trees, the botanist finds the following plants forming pure associations and each association may be distinguished by the generic name of the plant [1]).

April. *Asarum canadense, *Dicentra cucullaria, Erythronium americanum, *Claytonia virginica, *Pedicularis canadensis, *Epigaea repens, *Thaliotrum dioicum.

May. *Solea concolor, *Podophyllum peltatum, *Triosteum perfoliatum, *Tradescantia virginica, *Mertensia virginica, *Caulophyllum thalictroides, *Hydrophyllum virginicum.

July. Gaultheria procumbens.

The following ferns are also found in pure association in the forest: Adiantum pedatum, Nephrodium (Aspidium) spinulosum, marginale, acrostichoides and Phegopteris.

Along the woodland streams, growing in the damp loamy soil of such situations and controlled by the amount of soil-moisture present are a number of associations characterized by a single plant, as follows:

April. Floerkea proserpinacoides.

May. *Polemonium reptans, *Valerianella chenopodifolia, *Ornithogalum umbellatum, *Heracleum lanatum.

June. *Lysimachia nummularia.

July. *Impatiens fulva, I. pallida, Thalictrum polygamum, Pilea pumila.

August. Epiphegus virginiana, Lobelia cardinalis, Commelina nudiflora, *C. virginica.

September. *Eupatorium purpureum.

The rocky outcrops in the woods consisting either of ledges or of angular boulders by frost action are covered by several well-characterized associations formed by pure growths of the following species:

*Camptosorus rhizophyllus, *Polypodium vulgare.

April. *Saxifraga virginiensis, *Aquilegia canadensis.

May. *Heuchera americana.

Besides these pure association of plants found in the woods of southeast Pennsylvania occur a large number of species, rich in number of individuals, but scattered on the forest floor, separated from each other by spaces filled up with other characteristic woodland species, likewise isolated. These plants,

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1) Those marked by an asterisk also occur in the vicinity of Washington, D.C. and in about the same association, according to my observations.

therefore, form a mixed vegetation which covers the ground except where the pure association of single species occur and give character to the herbaceous flora of such woodland areas. The following species may be included in this category. They are arranged in what follows according to the aspects i. e. according to the months in which they appear in flower.

Botrychium virginianum, Asplenium filix foemina.

April. Dentaria laciniata, Viola palmata, Ranunculus abortivus, Geranium maculatum, Arisaema triphyllum, Erigeron bellidifolium, Sanguinaria canadensis, Hepatica triloba, Anemonella thalictroides, Aralia (Panax) trifolia, Mitella diphylla, Viola labradorica (V. canina var. Muhlenbergii), V. blanda, V. villosa, V. pedata, Carex pennsylvanica, Barbarea vulgaris, Ranunculus fascicularis.

May. Osmorrhiza longistylis, Smilacina racemosa, Viola pubescens, Aphyllon (Thalesia) uniflorum, Oxalis stricta, Oakesia (Uvularia) sessilifolia, Trientalis americana, Polygonatum giganteum, Medeola virginica, Orchis spectabilis, Hypoxis erecta, Tiarella cordifolia, Hydrastis canadensis, Thaspium trifoliatum var. aureum, Aralia nudicaulis, Cypripedium acaule, Allium tricoccum, Arisaema dracontium, Hieracium venosum, Oxalis violacea, Uvularia perfoliata, Smilax herbacea, Geranium maculatum, Luzula campestris, Ranunculus ficaria.

June. Pirola rotundifolia, Galium triflorum, Cynoglossum virginicum, Corallorhiza odontorhiza, Uvularia grandiflora, Scutellaria serrata, Liparis liliifolia, Cypripedium pubescens, Cypripedium parviflorum, Hieracium Gronovii, H. scabrum, Chimaphila maculata, Galium aparine.

July. Cimicifuga racemosa, Laportea canadensis, Chelone glabra, Panicum dichotomum, Lilium canadense, Monotropa uniflora, Prunella vulgaris, Silene stellata, Phryma leptostachya.

August. Lobelia syphilitica, Solidago bicolor, Aster macrophyllus, Panicum microcarpus.

September. Aster laevis, Solidago caesia, Collinsonia canadensis.

*Hemlock Formation.* This formation occurs on the sloping hillsides and precipitous banks of streams. The forest of hemlock consists in a few places of a pure growth without the admixture of any other tree species, but usually associated with the hemlock, *Tsuga canadensis*, the botanist finds the beech, *Fagus americana* and red maple, *Acer rubrum*. These trees are tolerant of the dense shade of the hemlocks. Where the forest has not been disturbed, sapling hemlocks, beeches and red maples are present ready to replace the dominant trees when they have succumbed to the wind. On the floor of the forest we find a Lycopodium Association of *L. lucidulum*; the laurel, *Kalmia latifolia*, occurs in the drier soils and forms a thicket, and the Mitchella-Association of *M. repens* carpets the ground with *Viola rotundifolia* as a character-plant, with which grows *Goodyera pubescens*, *Cinna latifolia*, *Hieracium paniculatum*, and in late summer *Aster divaricatus.* — In many places, the hemlock, forms an element in the mixed deciduous-forest formation. When such is the case, it is found in isolated patches usually of a few trees near the water-courses on steep hillsides. It forms then an association (Tsuga Facies) and with *Lycopodium lucidulum* are found three other species, viz., *L. annotinum*, *L. clavatum*, *L. dendroideum* which grow near the hemlocks. Two alternative hypotheses may be adduced for this. Either an original hemlock forest has been replaced by a deciduous one, or occasional hemlock trees have been under certain edaphic conditions developed amidst the component species of the deciduous forest.

### 3. River Bluff Formation.

*Wooded Rock Cliff Formation.* This formation is typically developed according to the observations of JOHN W. HARSHBERGER[1]) at the Delaware Narrows, Bucks County, Pa, where the Delaware River sweeps eastward, so that the palisades (Nockamixon Rocks) of red shale occur on the south shaded bank of the river and although the soil is extremely dry yet such slopes are always more cool than the surrounding country. These cliffs (300 feet high) are seamed by deep ravines down which small streams tumble in wet weather. A sharp talus slope occurs at the base of the precipitous cliffs and a number of rock shelves stand out from the face of the rocks.

The vegetation of these cliffs is of a more northern character than the surrounding vegetation. The talus slopes are covered by such trees as Acer saccharum, Betula lenta, Fagus americana, (comparable to the Maple-Birch-Beech Facies of the Adirondacks , Tilia americana, Tsuga canadensis, Betula nigra, Acer rubrum, Quercus coccinea, Q. alba, Q. rubra, Ulmus americana, U. racemosa (= U. Thomasi), Liriodendron tulipifera, Populus grandidentata, while the secondary trees are Rhododendron maximum, Hydrangea arborescens, Acer pennsylvanicum, Hamamelis virginiana, Taxus canadensis (in dense masses of pure growth on the shingly shale), and the shrubs Physocarpus opulifolius, Rubus odoratus, Viburnum acerifolium, Staphylea trifolia, Sambucus pubens, Celastrus scandens, Ampelopsis quinquefolia, Rhus radicans and many herbs as Asarum, Mitella, Sanguinaria, Viola and Aquilegia canadensis, Smilacina, Arisaema, ferns as Adiantum pedatum, Nephrodium, Botrychium, and on the rocks Camptosorus rhizophyllus, Polypodium and Cystopteris bulbifera. Quercus Prinus is the prevailing tree on the sloping top of the cliffs above the precipitous portion in the dry soil, together with Juniperus virginiana (occasionally wind swept), Ostrya virginiana, Carya porcina (= Hicoria glabra) and ovata, Rhus typhina, Morus, Sassafras etc.

The flat shelves on the face of the cliff are occupied by some of the above plants, Ostrya, Juniperus virginiana, with Ulmus, Celtis, Acer saccharum, Prunus virginiana, Juglans cinerea, etc. Underneath the shelving and projecting rocks at the top of the deep ravines, where evaporation of the dripping water by ascending currents of air through the ravine clefts makes the habitat an exceptionally cool one, is found Sedum Rhodiola in pure association, and on other more sunny slopes Sedum telephium grows. Asplenium ebeneum, Polypodium vulgare and Woodsia ilvensis are rock ferns in these ravines together with such herbs as Arabis lyrata and Cerastium oblongifolium, while Marchantia polymorpha clings to the dripping rocks. Such ravines recall the cliffs at Smugglers Notch in the Green Mountains of Vermont previously described (see ante p. 378). The forest of these ravines has a somewhat different composition on the cliff tops and talus slopes. Here grow Fagus, Tsuga, Tilia americana, Betula lutea, Morus rubra, together with Rhododendron maximum (in thickets along the streams), Hydrangea arborescens and Taxus canadensis.

## b) Southern Area.

The differences in the character of the forests of the Piedmont Plateau in the southern states are the result of the influence of variations in the quality of the soils, and in the altitude above sea level. The lowlands of the Piedmont Plateau, instead of embracing broad swamps, are confined to narrow borders of sedimentary origin along the streams. The loamy alluvial lands contiguous to the smaller streams have in all parts of the plateau very nearly the same kind of growth viz., *Fagus americana*, *Quercus rubra*, *Acer rubrum*,

1) The Plant Formations of the Nockamixon Rocks, Penna. Bulletin of the Torrey Botanical Club XXXVI, Dec. 1909 with map and 4 figures in the text.

*Liriodendron tulipifera*, while with these are associated many smaller trees: *Ostrya virginiana*, *Magnolia umbrella* (= *M. tripetala*), *Cornus florida* which sometimes are sufficiently numerous in North Carolina to form a thin underwood. If these soils become silty, *Liquidambar styraciflua*, *Nyssa sylvatica*, *Quercus lyrata*, *Q. Michauxii* and other trees which are more representative of the forests along the larger streams become conspicuous supplanting first the beech and oak, then the white oak and *Liriodendron*, and finally entirely taking their place.

*Deciduous Forest Formations.* The forest on the silt, or mud alluvium of the larger streams, consists of these supplanting trees with *Platanus*, *Celtis* and *Carya amara* (= *Hicoria minima*). *Nyssa, Carya amara* and *Platanus* are uniformly distributed throughout, although no where abundant, or forming a conspicuously large portion of the growth. These trees also enter into the composition of the mountain forests. The other trees, however, are sparingly distributed westward toward the mountains. Eastward *Acer saccharum* occurs with it in cooler places as the altitude increases. Beneath the taller trees occur *Carpinus caroliniana*, species of *Crataegus* and *Asimina triloba.* All the open banks in full sunlight are lined with *Salix nigra* and *Betula nigra.*

*Upland Forest Formation.* The upland forests of the Piedmont Plateau are composed of broad-leaf species and pine. The body consists of oaks with more or less hickory and in places the short leaf pine *Pinus mitis* (= *P. echinata*) is scattered among them. The original forest may be separated into three parallel strips (1) the eastern pine strip; (2) the broad leaf forest strip; (3) the western pine strip. The eastern pine strip may be divided into the forests of the eastern granite areas, of the eastern red sandstone, and of the slates. The forest of the eastern granite areas consists of *Quercus obtusiloba* (= *Q. minor*), *Q. tinctoria* (= *Q. velutina*), *Q. alba*, *Q. falcata* (= *Q. digitata*), with a considerable admixture of *Carya tomentosa* (= *Hicoria alba*), *Carya porcina* (= *Hicoria glabra*) and in most places *Pinus mitis.* Along the hollows and cooler slopes are *Quercus alba, Q. tinctoria*, *Q. rubra*, *Liriodendron.*

The forest of the eastern red sandstone strip consists of an upper dominant story of *Pinus mitis* with an underwood of *Quercus obtusiloba*, *Q. falcata*, *Q. alba*, *Hicoria alba*, and *Quercus marylandica* (= *Q. nigra*).

The forest of the slate soils where better drained resembles a two-storied high forest. The upper story consists of a rather open growth of *Pinus mitis* and the lower story of small *Quercus obtusiloba*, *Q. marylandica*, with more or less *Quercus falcata*, *Q. alba*, *Carya tomentosa.* The trees are often shrubby. As the soil becomes poorly drained the pine decreases until on the "willow oak (*Quercus phellos*) flats" the growth becomes restricted to *Quercus obtusiloba*, *Q. marylandica* as a lower story slightly overtopped by *Quercus phellos.*

The deciduous forests of the Piedmont Plateau were originally compact consisting of oaks and hickories with pine only on rocky or sandy soils along the crests of hills. On the red loams the trees are *Quercus tinctoria*, *Q. alba*, *Carya tomentosa* with a small intermixture of Spanish oak *Quercus falcata* and

along the crest of ridges *Quercus obtusiloba*, but on the lower hillsides and steep north slopes is found *Liriodendron*, *Quercus rubra*, *Carya alba* (= *Hicoria ovata*), and *Fraxinus americana* also occurs. The forest of the loose gray loams is composed of *Quercus alba*, *Q. falcata*, *Q. obtusiloba*, *Q. tinctoria*, *Carya tomentosa* (= *Hicoria alba*) and *Quercus coccinea* in abundance in the order named, and forming over three-fourths of the growth. As undergrowth we find *Cornus florida*, sour wood *Oxydendrum arboreum* and species of *Crataegus* [1]), *Rhamnus* and *Viburnum*.

Lying to the west of the compact red and gray loams are finegrained and mostly sandy loams, usually red or reddish in color with a thin surface soil extending to the base of the Blue Ridge and its outlying spurs, constituting the western pine land. The trees of the forest on these soils stand in relative abundance about in the following order: *Pinus mitis*, *Quercus coccinea*, *Q. tinctoria*, *Q. alba*, *Oxydendrum arboreum*, *Q. Prinus*, *Q. obtusiloba*, *Q. falcata* and *Carya tomentosa* (= *Hicoria alba*). These trees form considerably over three-fourths of the growth. Less abundant and forming the larger portion of the remainder of the growth are *Cornus florida*, *Carya porcina* (= *Hicoria glabra*), *Castanea americana*, *Quercus marylandica*, *Pinus inops*, *Nyssa sylvatica*, *Acer rubrum* and *Corylus rostrata*, *Hamamelis*.

Nothing has been published and the writer has no observations of his own to offer on the herbaceous plant associations of the Piedmont Plateau in North Carolina, but the flora of this region is quite similar in general character to that of the whole district lying at the same elevation from New England to Alabama. A comparison of the flora of middle Georgia with that of Southern New England shows that at least half of the species of each region are common to both. A brief consideration of the plant formations of middle Georgia is here represented [2]).

Of greatest interest perhaps are those species which inhabit the rich shady primeval forests on the north sides of the hills: Botrychium virginianum, Adiantum pedatum, Asplenium ebeneum, Polystichum acrostichoides, Poa brevifolia, Carex laxiflora, Tradescantia montana, Uvularia perfoliata, U. puberula, Smilacina racemosa, Polygonatum biflorum, Medeola virginica, Dioscorea villosa, Silene stellata, Cimicifuga racemosa, Xanthorrhiza apiifolia, Hepatica, Anemone thalictroides, Sanguinaria, Dentaria laciniata, Heuchera americana, Geranium maculatum, Viola palmata, V. hastata, Aralia (Panax) quinquefolia, Pedicularis canadensis, Mitchella repens, Solidago caesia.

In drier more open woods, including those on the south sides of hills and the second growth oak woods which are frequent on the broad summits of the ridges, the forest consists of Juglans nigra, Caryas, Quercus, 6 spec., Prunus serotina and Aesculus flava; shrubs or trees beneath the dominant ones: Castanea pumila, Asimina triloba, Cercis, Rhus, Euonymus, Ceanothus, Vaccinium

1) Pinchot, Gifford and Ashe, W. W.: Timber Trees and Forests of N. Carolina, Bulletin No. 6. North Carolina Geological Survey 1897.

2) Harper, Roland M.: Notes on the Flora of middle Georgia. Bulletin Torrey Botanical Club XXVII: 320—341 June 1903. See also, Some coastal plain Plants in the Piedmont Region of Georgia. Bulletin Torrey Botanical Club XXXVI: 583—593 where it is suggested that the plants common to the coastal plain and the Piedmont must have been more widely distributed in the highlands than they are now having pushed ont from a climax region into the coastal plain occupied by pioneer formations. Cf. this book, pages 201—203; 212—215.

stamineum, V. corymbosum, and such lianes as Vitis, Ampelopsis, Gelsemium sempervirens and Smilax rotundifolia. — The herbaceous plants of these woods are Panicum commutatum, Stipa avenacea, Melica mutica, Uniola latifolia, Danthonia sericea, Carex pennsylvanica, Hypoxis erecta, Silene virginica, Anemone virginiana, Ranunculus fascicularis, Lespedeza hirta, Linum virginianum, Jatropha stimulosa, Viola pedata, V. villosa, Sanicula canadensis, S. marylandica, Chimaphila maculata, Gentiana villosa, Asclepias variegata, Hedeoma pulegioides, Calamintha (Clinopodium) caroliniana, Salvia urticaefolia, Scutellaria integrifolia, S. pilosa, Gerardia tenuifolia, Elephantopus carolinianus, Solidago brachyphylla, S. petiolaris, S. erecta, Aster patens, Chrysogonum virginianum, Coreopsis major, Hieracium venosum.

*Lowland Forest Formation.* The river banks are occupied by certain trees and shrubs which flourish best there: *Carpinus caroliniana*, *Ostrya virginiana*, *Betula nigra*, *Fagus americana*, *Quercus aquatica*, *Ulmus americana*, *Morus*, *Liriodendron*, *Platanus*, *Salix nigra*, *Asimina triloba*, *Acer rubrum*, *Negundo*, *Tilia pubescens*, *Fraxinus*; as shrubs, *Alnus serrulata*, *Calycanthus*, *Philadelphus*, *Amelanchier*, *Ptelea*, *Rhododendron (Azalea) nudiflorum*, *Kalmia*, *Leucothoë Catesbei*, *Vaccinium arboreum*, *Symplocos tinctoria*, *Styrax americana*, *Chionanthus*, *Cephalanthus*, *Arundinaria tecta*.

Along the rivers in deposits of dry sand certain psammophilous species form associations in Georgia, viz., *Pteris aquilina*, *Yucca filamentosa*, *Lupinus perennis*, *Opuntia vulgaris*, *Vaccinium arboreum*, *Breweria humistrata*, *Monarda punctata*, *Chrysopsis graminifolia*.

The Piedmont flora reaches its southern limit in the region of the Tallapoosa and Coosa rivers in eastern Alabama. Here these plants mingle with many from the Gulf coastal plain and with a number of local species sparsely scattered throughout the south, such as Dryopteris floridana, Ophioglossum crotalophoroides, Lycopodium alopecuroides. The following plants, decidedly with a northern range of distribution, seem to find these highlands their southern limit: Uvularia perfoliata, U. sessilifolia, Smilacina racemosa, Trillium stylosum, Polygonatum biflorum, Smilax echirrhata, Habenaria lacera, Asarum virginicum, Asimina triloba, Hydrangea arborescens, Philadelphus grandiflorus, Chimaphila umbellata, Rhododendron (Azalea) viscosum var. glauca, Hieracium venosum, etc.

## B. Appalachian District.

This district is coincident with the Appalachian Mountain ranges which extend from southern New York into the state of Georgia. On the northwest lies the great Alleghany Plateau, and on the southeast the Piedmont Plateau. These mountain ranges are composed mainly of ridges, whose longitudinal direction is from northeast to southwest. Between these ridges valleys are found. This system of mountains is naturally divided into two parts, the northern Appalachian and the southern Appalachian ranges.

The flora of these mountains is essentially composed of a decidous forest of broad-leaf trees which surrounds the island-like areas of coniferous vegetation on the higher mountain summits, noticeably in North Carolina and Tennessee. The broad-leaf species which in early days covered the valley-lands ascended the mountain slopes, dominated the crests and summits of the lower mountains, filled all the intervening country between the ranges and only gave place to the coniferous forest of northern range on the higher mountain

summits and table-lands. Some plant geographers, among them MERRIAM, would place the higher mountain areas with the great northern coniferous forest, because they consider the forests of the highest mountains to be an extension southward of the northern forest. In all likelihood, as previously described (pages 209—212), the trees of the northern forest, north of the great terminal moraine, have been derived from farther south and in all probability the coniferous forest formation and associations came from the higher Appalachian ranges in the middle and southern states. The writer, therefore, on historic grounds considers it best to include these isolated mountain forests surrounded on every side by a sea of broad-leaf trees, and removed hundred of miles from the pure coniferous forests of the north with the forest formations and associations of the Appalachian Mountain District of our classification. This it seems to him is the natural method of treatment, first, because these forests in the minds of the laity are associated with the country where they are found, and second, because the deciduous trees of the lower forests mingle with and modify the coniferous formations and associations, producing tension lines which in peculiar manner modifies and alter the facies of the vegetation.

## a) Northern Mountain Area.

The Appalachian mountain ranges enter southeastern New York terminating in the Catskill Mountains and Shawangunk Mountains. The streams of this area heading in the Alleghany Plateau on the west run southeastward into the Atlantic Ocean and cut through the ranges by great gorges, that are popularly called water gaps; but south of New River the Appalachian ranges are drained into the Gulf. New River (Great Kanawha) and the James River represent the southern boundary of the northern mountain phytogeographic area.

### 1. Territorial Remarks on the District.

Exposure and situation have much influence on the distribution of plants in these northern Appalachians. Thus on Spruce Creek a tributary of the Juniata in Pennsylvania where this stream has produced a talus by its erosive action grow *Sorbus americana*, *Betula papyrifera*, *Ribes prostratum*, *Heuchera pubescens*, and *Linnaea borealis*. In contrast to this association, we find scarce two hundred yards away a narrow intervale bordering the stream where on the alluvial bottom grows the southern papaw, *Asimina triloba*. *Aristolochia sipho* also occurs climbing up *Juniperus virginiana* in this bottom [1].

The original condition of the flora of the Catskills has been much disturbed by the removal of the marketable trees by lumbermen and by the settlement of the country. The list of introduced plants is a large one and among them are many noxious weeds. Originally the woods were damp owing

1) BUCKHOUT, W. A.: Northern Plants in Pennsylvania. Garden and Forest 1891, IV: 447.

to the numerous mountain streams, but with the removal of the timber many hillsides have been thoroughly dried and support, therefore, an entirely different set of plants [1]). There are practically only seven plant formations according to the observations of the writer displayed in the Catskill mountains [2]). These formations may be enumerated as follows: deciduous forest formation, coniferous forest formations (three in number) lake plant formation, marsh plant formation and rocky ledge plant formation.

The flora of the Kittatinny or Shawangunk Mountains of northwestern New Jersey is peculiar. This mountain chain forms a wall of almost constant altitude, averaging from 1,200 feet in height, along the eastern side of the Delaware River from Port Jervis to the Delaware Water Gap. Its summits and western slopes are composed of a coarse or fine, very hard silicious conglomerate or sandstone, with little soil but that derived from the limited disintegration of these rocks, and it is therefore highly silicious. While the mountain sides are extensively glaciated there is very little glacial drift on the ridge.

On these mountains exist a number of plants which are also found in great numbers in sandy soil along the Atlantic coast [3]). Among the species which are thus noteworthy, as discovered by N. L. BRITTON, are: Juncus Greenei, Solidago puberula, Orontium aquaticum, Tephrosia virginiana, Lespedeza hirta, Lupinus perennis, Quercus ilicifolia, Corema Conradii. At Culver's Gap were found by Britton: Polygala polygama, Gerardia pedicularis, Lechea racemulosa, all abundant in sandy soil along the coast, and Prunus pumila. At Sunfish Pond, northwest of the Water Gap, occur Juncus militaris, Lycopodium inundatum, Viburnum nudum. While all along the mountains grow Aster linariifolia, Quercus ilicifolia, Gaylussacia resinosa, G. frondosa, Vaccinium vacillans, Epigaea repens, Gaultheria procumbens, Lyonia (Chamaedaphne) calyculata, Azalea (Rhododendron) viscosa. Another peculiarity is the substitution of Pinus rigida on the mountains for Pinus Strobus of the surrounding country.

The ridges of the Green Pond system, known at Greenwood Lake as Bearfort and Bellvale mountains, and in New York as the Skunnemunk, have a somewhat similar summit flora, consisting of Quercus ilicifolia, Solidago puberula, Tephrosia virginiana, Lespedeza hirta, Arctostaphylos uva-ursi, Aster linariifolia, various huckleberries, blueberries and other sand plants.

The flora of the mountainous parts of Pennsylvania is divided by the Susquehanna River into two parts. The elevated mountain region in the northeast abounds in ponds and lakes, sphagnous bogs, forests and large open tracts almost destitute of trees. The dominant trees found for example on the Pocono Plateau are *Pinus strobus*, *Picea nigra* (= *P. mariana*), *Abies balsamea*, *Betula lutea*, *B. papyrifera*. The original vegetation of this plateau

1) The important papers on the Catskill flora according to Dr. John H. Barnhart of the New York Botanical Gardens are: Hall, J. H.: Catskill Ferns. Bulletin Torrey Bot. Club V: 38—39. 1874; Mearns, E. A.: A List of the trees and shrubs collected (in the Catskills) Proceedings U. S. National Museum XXI: 343, 1898; Britton, E. G.: Mosses of the Catskills. Torreya I: 84, 1901.

2) HARSHBERGER, JOHN W.: The plant Formations of the Catskills. Plant World VIII: 276—281. Nov. 1905.

3) HARSHBERGER, JOHN W.: The comparative Age of the different floristic Elements of eastern North America. Proceedings Academy Natural Sciences 1904: 606.

consisted, as far as I have been able to determine, of four elements, viz., a forest of pitch pine, *Pinus rigida,* which covered the looser morainic material of the great terminal moraine in the eastern and southern parts of the plateau; the broad-leaved deciduous forest with its oaks and associated species on the eastern slopes and edges of the tableland; the chestnut and black locust forest which occupied Laurel Ridge along the western rim of the plateau, and a forest of white pine with a thicket of *Rhododendron maximum*, beneath, mixed in many places with the black spruce, the red maple and other plants characteristic of the Catskill Mountains and farther north, grading over to a hemlock forest in the region of the Tobyhanna. The open sphagnum bogs culminate in the presence of the larch, *Larix americana* with which were associated *Kalmia glauca*, *Ledum latifolium*, *Rhododendron Rhodora* and other northern plants. With the destruction of the white pine, hemlock and pitch pine forests, the vegetation of this tableland has undergone an entire change. The succession of the species has not been worked out in detail, but what has been observed is instructive. The botanist is impressed by the general appearance of the landscape. The flora over the eastern half of the plateau in aspect resembles that of the pine barren regions of southern New Jersey, from which the original pitch pine and Jersey pine have been cut. A study of the species shows that this appearance is due to the close similarity of the flora in the plant species which constitute the two regions. We have an instructive example of mass invasion of such plants as *Quercus ilicifolia, Pinus rigida*, *Gaylussacia resinosa*, *Vaccinium vacillans*, *Epigaea repens*, *Gaultheria procumbens*, *Rhododendron viscosum*, *Kalmia angustifolia*, *Lilium philadelphicum*, *Amianthum muscaetoxicum*, etc., from the morainic hills westward into the region occupied by the white pines, while *Orontium aquaticum*, now thoroughly established, may have been introduced by the Indians. We naturally inquire from what locality the pitch pine formation has proceeded, and it seems to me we are forced to conclude that this association of species has been derived, not from the barrens of New Jersey, but from the nearby mountains northwest of the Delaware Water Gap which, as previously mentioned, support such a flora (See ante page 221).

The entire mountainous country in western Maryland between Savage Mountain on the west and Sideling Hill on the east was once a continuous forest. The prevailing growth is deciduous, but this is conspicuously mingled with patches, and often large areas of conifers which occupy small detached hills. In other cases similar hills bear a growth chiefly of conifers on their north slopes and a deciduous forest on their south slopes. In ascending for example one side of a mountain *Fagus americana*, *Tilia americana* may appear at the base of the mountain, while above in a second belt occur *Quercus Prinus*, *Pinus pungens*, *Prunus pennsylvanica*. The predominant trees of the country, *Q. rubra*, *Castanea americana*, *Quercus alba*, occur on all low hills and middle slopes and benches of the high mountains. *Quercus Prinus* appears on the upper, rocky gravelly slopes and summits of the mountains and hills. *Castanea*

is confined chiefly to poor, dry gravelly, southern, eastern and western slopes. *Quercus rubra* is associated with the above trees [1]).

## 2. Broad leafed and Coniferous Forest Formations.

*Deciduous Forest Formation.* The valleys and mountains except the summits of the highest Catskill Mountains are covered with a deciduous forest which ascends to about 3,500 feet. It is a mixed one consisting of such dominant trees as *Fagus americana*, *Castanea americana*, *Quercus rubra*, *Juglans cinerea* *J. nigra* (sparingly), *Betula lutea*, *B. lenta*, *B. populifolia*, *B. papyrifera* (uncommon), *Acer saccharum*, *Populus tremuloides*, *P. grandidentata*, *Ulmus* etc., while near the streams in this forest are found *Platanus occidentalis*, *Carpinus caroliniana* and such shrubs as *Alnus serrulata*, *Hamamelis*, *Sambucus* and *Amelanchier canadensis*. The absence of *Liriodendron tulipifera*, many of the oaks, hickories, magnolias and other deciduous trees is noteworthy. As the botanist ascends the mountains and when an elevation of 2,880 feet is reached, the constitution of this type becomes more uniform by the disappearance of such trees as *Castanea*, *Quercus rubra*, *Tilia*, *Juglans cinerea*, *Ulmus*.

The herbaceous plants, or partially woody plants of the forest floor that exist in the shade of the broad-leaved forest trees are, according to my observations: Hepatica triloba, H. acutiloba, Uvularia (Oakesiella) sessilifolia, Solidago caesia, Sanguinaria canadensis, Geranium Robertianum, Eupatorium ageratoides, Viola palmata, Anemone nemorosa, Smilacina racemosa, Streptopus roseus, S. amplexifolius, Asarum canadense, Maianthemum canadense (ascending to considerable altitudes), Polygonatum biflorum, Erythronium americanum, Medeola virginica, Epiphegus virginiana (on beach roots), Monotropa uniflora, Corallorhiza odontorhiza, Actaea alba, Caulophyllum thalictroides, Dicentra canadensis, D. cucullaria, Viola pubescens, V. canina, Tiarella cordifolia, Mitella diphylla, Aralia nudicaulis, A. hispida, A. trifolia, A. quinquefolia, Aster cordifolius, Mitchella repens (dry woods), Trillium erectum, T. erythrocarpum (= T. undulatum), Aster acuminatus, Arisaema triphyllum associated with many ferns (Polystichum and Phegopteris, Cystopteris, Adiantum pedatum, Asplenium, Dennstaedtia punctilobula, Lycopodium (4 species) and club mosses) [2]).

Farther to the south in Pennsylvania the slopes and valleys of these mountains are clothed with deciduous forests, where *Liriodendron tulipifera*, *Tilia americana*, *Acer saccharum*, *Robinia pseudacacia* occur with *Quercus alba*, *Q. Prinus*, *Q. rubra*, *Q. coccinea*, *Q. tinctoria*, *Q. bicolor*, *Castanea*, *Fagus*, *Juglans*, *Hicoria* (5 spec.), *Platanus*, *Carpinus*, *Fraxinus americana*, under different combinations and associations form a forest of great diversity of light and shadow. *Quercus Prinus*, *Robinia pseudacacia*, *Castanea americana*, all may be expected to grow in association along those mountain slopes where the Medina and Oneida sandstones appear, neither altitude nor the rocks seem to prevent their growth. *Carya alba* (= *Hicoria ovata*) and *C. porcina* (= *Hicoria glabra*) are trees of lower ground. The former seldom leaves the alluvial grounds;

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1) SUDWORTH, GEORGE B.: The Forests of Alleghany County. Maryland Geological Survey Alleghany County 1901: 263—278.

2) I am indebted for some of the details presented here to Miss Lily Wells of Newport, R. I. who with her brother (now deceased) made water color paintings of Catskill plants, also to Miss Martha H. Hollinshead of Moorestown, N. J.

the latter though often found on higher levels seldom reaches the mountain tops. *Juglans cinerea* grows along streams even high up on the mountain side, but the black walnut *J. nigra* is seldom found on the rocks of the higher steeper slopes [1]). *Gymnocladus canadensis* and *Rhamnus lanceolatus* occur in the limestone Cumberland Valley near the Potomac River.

Considered in general three kinds of forest types occur in Maryland, viz., ridge forests, slope forests and swamp forests [2]). The ridge forest occupies the benches and broken rocky crests and is essentially distinguished by the predominance of *Castanea*. The slope forest contains the largest number of species. On the steep slopes above the Youghiogheny River, it is often pure growths of *Tsuga canadensis*, in the richer coves almost pure *Quercus alba*. Between these two extremes there are slopes upon which *Tsuga* and the hardwoods mingle while on other slopes *Castanea* predominates. The association of species is as below mentioned in the order of their importance.

| Dominant. | Secondary. | |
|---|---|---|
| Castanea americana Raf. (= C. dentata Marsh). Quercus alba L. | Acer saccharum Marsh.<br>Quercus rubra L.<br>Tilia americana L.<br>Betula lutea Michx. f.<br>Betula lenta L. | Fagus americana Sweet.<br>Quercus prinus L.<br>Tsuga canadensis L.<br>Pinus Strobus L.<br>Acer rubrum L. |
| Tsuga canadensis L. and Hardwoods. | Acer saccharum Marsh.<br>Fagus americana Sweet.<br>Tilia americana L.<br>Betula lutea Michx. f.<br>Quercus alba L.<br>Castanea americana Raf. | Quercus rubra L.<br>Betula lenta L.<br>Quercus Prinus L.<br>Pinus Strobus L.<br>Acer rubrum L. |
| Tsuga canadensis L., hemlock. | Betula lutea Michx. f.<br>Acer saccharum Marsh. (sugar maple).<br>Fagus americana Sweet.<br>Tilia americana L.<br>Acer rubrum L. | Quercus alba L.<br>Pinus Strobus L.<br>Betula lenta L.<br>Castanea americana Raf.<br>Quercus rubra L.<br>Quercus Prinus L. |

The swamp forest has fewer species than the others *Picea nigra*, *P. rubra* with *Pinus Strobus* are the principal trees, and a varying amount of hemlock. The areas occupied by this type surround and extend into the swamps and sedge-covered tracts along the streams known as glades or mountain meadows. Where *Pinus Strobus* is predominant occur in the following order *Tsuga*, *Acer rubrum*, *Betula lutea*, *Castanea americana*, *Quercus alba*, *Q. rubra*, *Tilia americana*, etc. Where *Picea nigra* (= *P. mariana*) is dominant, *Tsuga*, *Betula lutea*, *Acer rubrum*, *Fagus americana*, *Acer saccharum*, *Pinus Strobus*.

1) Rothrock, J. T.: Forests of Pennsylvania. Proceedings of the American Philosophical Society XXXIII 1894: 114—133.

2) Curran, H. M.: The Forests of Garrett County. Maryland Geological Survey 1902: 303-319.

The shrubby undergrowth consists of Sorbus americana, Rhus hirta, R. copallina, Aralia spinosa and Kalmia latifolia on the drier soils; along streams Asimina triloba, Hamamelis virginiana, Pirus coronaria, Amelanchier canadensis, Crataegus coccinea, Cercis canadensis, Cornus alternifolia. Acer pennsylvanicum and spicatum are found on the steep river slopes and Rhododendron maximum and Viburnum lentago in the swamps.

The herbaceous plants of such forests as they occur in West Virginia are mentioned below: Trautvetteria palmata, occurs along deeply shaded mountain rills. Aconitum uncinatum grows along banks of rivers, while Actaea alba and A. rubra with Cimicifuga racemosa are on the higher mountains. Dicentra eximia is also at high elevations. Lycopodium lucidulum, L. annotinum, L. dendroideum, L. clavatum and L. complanatum are all found in the forests of Picea nigra along the mountains at 2,500—4,800 feet in altitude with Abies balsamea and Pinus Strobus.

*Coniferous Forest Formation.* These exist in the Catskill Mountains in three types determined by the dominant tree of each type. They are the Tsuga-facies, Strobus-facies and Abies balsamea-facies.

Tsuga Facies. Formerly the hemlock, *Tsuga canadensis*, grew in considerable abundance in the Catskill Mountains. It formed pure growths along the steep slopes of mountain streams, or on the northern shaded shoulders of ridges descending into the principal valleys. It was much sought as a bark and timber producing tree and much of the best hemlock has been removed long since from the Catskill forest. One isolated grove in Big Indian Valley was studied by the writer, and it may be taken as a type of the original hemlock formation. *Tsuga canadensis* is the dominant tree associated with *Fagus americana*, *Acer rubrum*, *A. saccharum* and *Betula lutea*, which are sparingly present in this type of forest. On the ground the botanist finds *Mitchella repens*, *Viola rotundifolia*, *Lycopodium lucidulum*, *Chimaphila umbellata*, etc. while *Kalmia latifolia* forms the shrubby undergrowth.

Pinus Strobus Facies. This at present is found in a few localities and it represents largely a second growth in the wider valleys not at any considerable elevation. As a formation, it occurs surrounded by the deciduous forest on the sunny lower slopes of mountains, exposed to the noonday sun. The white pine is the dominant tree in pure growth, while beneath the pines one finds much the same association of species as in the hemlock formation, such as, *Gaultheria procumbens*, *Chimaphila umbellata* and *Pirola rotundifolia*.

Abies balsamea Facies. Above 3,200—3,500 feet on the higher mountains, such as, Cornell, Wittenberg, Slide mountains the balsam, forms an almost pure growth, associated with *Picea nigra*, *Sorbus americana*, *Betula lutea*, *Prunus pennsylvania* and *Acer pennsylvanicum*, while the undergrowth of shrubs consists of *Viburnum lantanoides*, *Ribes prostratum*, *Sambucus racemosa*, *Rubus odoratus* (at lower elevations).

The herbs of this forest formation are Dennstaedtia punctilobula, Oxalis acetosella, Circaea alpina, Viola blanda, Clintonia borealis, Mitchella repens, Cornus canadensis, Coptis trifolia, Corallorhiza multiflora, Lycopodium lucidulum and on the mossy windfalls Cladonia rangiferina with Chiogenes hispidula. On the tops of the largest boulders occur in dense mats Polypodium vulgare and on their sides species of the lichen Umbilicaria. Vaccinium pennsylvanicum found in this formation arising from a mossy bed beneath the balsams is a shrub from a foot to two feet high and at the lower elevations in this formation are found Rhododendron (Azalea) viscosum and R. nudi-

florum. On Slide Mountain at an elevation of 3,500 feet on cliffs and ledges among the balsams Abies balsamea were collected, such mosses as Raphidostegium Jamesii, R. laxepatulum, Plagiothecium striatellum (= Hypnum Muhlenbeckii), P. Muellerianum, Hylocomium umbratum, H. pyrenaicum (= Hypnum Oakesii), Dicranum fuscescens and D. longifolium.

This balsam facies, according to my observations, covers the highest mountain peaks in the Catskills viz., Wittenberg (3,824 feet), Cornell (3,920 feet), Table Mountain (3,875 feet) and Slide Mountain (the highest dome, 4,200 feet). It extends down the mountain slopes in tongues into the deciduous forest below and at the lower elevations it breaks up into isolated patches easily delimited by the dark green color of such patches in a lighter green background. Its constitution is very similar to the topmost plant formations of the Adirondacks, and the mountains in Virginia, North Carolina and Tennessee.

In the mountainous parts of Pennsylvania we find an other arrangement of the Coniferous Forest Formation as follows[1]).

Pinus Strobus Facies. The dominant tree *Pinus Strobus* associated with *Picea nigra* (= *P. mariana*) formed on the higher tablelands of the northern Appalachian area an almost pure forest under which grew *Sorbus americana*, *Acer pennsylvanicum*, *Ribes lacustre*, *R. prostratum* and *Rhododendron maximum*. A magnificent growth of white pine once covered the slopes of the mountains and the sides of the ravines, overshadowing and enclosing the smaller streams, and attaining its best development about their headwaters. In the deep ravines it was usually associated with the hemlock *Tsuga canadensis*, *Betula lutea*, *Castanea americana*, *Acer rubrum* with an occasional *Fraxinus americana* and rarely *Liriodendron tulipifera*. It spread completely over many of the mountains growing in mixture with hemlock or making pure stands. At the top of the slopes, and upon the summits of the mountains on poor soil, *Pinus rigida* usually takes its place. The white pine in western Maryland occurs almost entirely on northern and eastern slopes, ascending to the summits of the highest mountains. It is especially abundant along the rocky north slopes of streams, often forming dense narrow belts of pure growth down to the water's edge.

Tsuga Facies (see plate XIb at p. 465). The hemlock is an element of the mountain flora. As a tree, it prefers the rocky sides of mountain gorges, or a rocky hillside overlooking a stream. Occasionally it appears in a deep forest on flat ground by a stream. It is very scarce along the southern border of the state, except in the mountains proper. It is frequently associated with the white pine and the association of species is much like that in the white pine forest only a few plants become more prominent among them such herbs on the ground as *Viola rotundifolia*, *Mitchella repens*, *Goodyera pubescens*, *G. repens*, *Spiranthes gracilis*, *Cypripedium acaule*.

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1) Consult SARGENT, CHARLES S.: Report on the Forests of North America. Tenth U. S. Census Vol. IX. 1880 pages 506—510 with map.

Pinus rigida Facies. One other formation probably exists, a displayed on the ledges at Kaaterskill overlooking the Hudson Valley, namely, that in which the pitch pine, *Pinus rigida* is the principal tree. As a tree this species occupies the higher mountains in Pennsylvania where it exists in barren soil and under xerophytic conditions. A number of ericaceous plants forms a part of this association, as well, as the barren places, viz. *Vaccinium canadense*, *V. pennsylvanicum*, *V. vacillans*, *V. nigrum*, *V. stamineum*, with such herbs as *Solidago odora*, *S. puberula*, *Kalmia angustifolia*, *Habenaria blephariglottis*, *Lygodium palmatum*, representative pine barren elements.

Other pines form an important element in the forest cover of very exposed, bare, rocky, southern slopes in western Maryland. *Pinus virginiana* (= *P. inops*) form a dense cover in the poorest shaly soils on the lower southern slopes of high ridges, or more frequently on the south side of low hills (Pinus virginiana Facies). At higher elevations comprising the middle benches and summits of mountains *Pinus rigida* and *Pinus pungens* occupy sterile rocky situations on southern, southeastern and southwestern exposures. Scattered individuals also occur mingled with hardwoods on the low shaly hill tops adjacent to the mountains. *Pinus mitis* is present in exceptional instances.

The Rocky Ledge Formation is found on the rocky ledges and bluffs which occur throughout the Catskill Mountains. The plants which characterize such ledges are mainly ferns[1]) and a few herbs which together may be enumerated here, as: Camptosorus rhizophyllus, Pellaea gracilis, Woodsia ilvensis, Saxifraga virginiana, Arabis lyrata, Polypodium vulgare, Asplenium trichomanes, Aquilegia canadensis, Heuchera americana, Polygonum cilinode, Campanula rotundifolia various species of lichens as of the genus Umbilicaria and blue green algae, Nostoc sp.

### 3. Pond- and Lake plant Formations.

The lake plant and the marsh plant formations are sparingly represented in the Catskills. One natural lake, or mountain tarn, was noted as the source of Stony Clove Creek already partially encroached upon by vegetation to produce a marsh. In the absence of a detailed study, these formations are merely mentioned to complete our classification of the principal formations in the Catskill Mountains.

In West Virginia above the great terminal moraine exist a considerable number of ponds and lakes which represent water filled kettle holes or streams damned by glacial material. In these ponds *Nymphaea odorata*, *Nuphar advenum*, *N. Kalmianum*, species of *Potamogeton* represent the floating aquatic vegetation. *Calla palustris*, *Dulichium spathaceum*, *Sarracenia purpurea*, *Drosera rotundifolia* and *D. intermedia* sometimes form floating masses detached from the edge of the pond. The open water is surrounded by a fringe of sedges (*Carex* etc.) and *Sarracenia*, and these plants in turn by *Lyonia* (*Chamaedaphne*) *calyculata*, into which *Larix americana* encroaches with occasional specimens of pine *Pinus rigida*.

1) POYSER, W. A.: The Fern Flora of Pennsylvania. The Fern Bulletin XVII: 65. July 1909.

*Bog Formation.* All of the sphagnum bogs in the moraine covered terr tory in the mountains represent ponds and lakes that have been converte into bogs by the slow encroachment of vegetation. The basis of the bog : sphagnum. Near the center where the sphagnum mass has not been corr pacted a quaking bog exists with the peaty material sometimes as I hav determined by actual measurement 12—15 feet deep[1]). The pure sphagnur stretches are usually occupied by *Sarracenia purpurea*, *Scheuchzeria palustri. Vaccinium macrocarpum*, *Kalmia glauca* form an association to be replaced i other situations by an almost pure growth of *L.* (*Chamaedaphne*) *calyculata* c associated with *Kalmia angustifolia*, *Vaccinium corymbosum*, *Ledum latifoliu*, surrounded by sedges *Dulichium spathaceum*, *Carex bullata*, *Eriophorum va ginatum* and others. *Larix americana* encroaches also on such open bogs.

The edge of such bogs is characterized by a fringe of plants: Nemopanthes fasciculari Kalmia glauca, Lyonia calyculata, Vaccinium corymbosum, Rhododendron Rhodora with Lys machia stricta, Azalea viscosa. The smaller kettle hole bogs have been long converted int almost solid earth. Here occur in association Acer rubrum, Nyssa sylvatica, Picea nigra, Ile verticillata, Rhododendron maximum, Viburnum nudum, Nemopanthes fascicularis, Sassafras offic nale, Betula populifolia, Prunus pennsylvanica, Rubus trifolia, Kalmia angustifolia, Vaccinium corym bosum and nigrum, while such ferns as Osmunda cinnamomea, Nephrodium noveboracense, Dry opteris, Thelypteris are denizens of rich bogs with such herbs as Dalibarda repens, Corni canadensis, Habenaria blephariglottis, Gentiana linearis, Aralia hispida, etc.

In central Pennsylvania high up in a horse-shoe of the mountains, i a peat bog which has not owed its origin to glacial action. It is in a regio where bogs and lakes are uncommon or almost unknown[2]). The center is . quaking bog of sphagnum and sedges: *Carex trisperma*, *C. utriculata* and th peat is here over ten feet deep. *Sarracenia purpurea*, *Menyanthes trifoliata Coptis trifolia*, *Calopogon pulchellus*, *Nemopanthes*, *Vaccinium macrocarpum Chamaedaphne calyculata*, *Alnus incana*, *Clintonia borealis* occur in this bog

## b) Southern Mountain Area.

This area occupies the southern Appalachian Mountains south of New Rive and extending to the northern confines of Alabama.

### 1. The Forest- and Cliff-Formations of the southern Alleghanies.

*Coniferous Forest Formation of the Lower Hills.* The area in which *Pinu mitis* (= *P. echinata*), *Pinus rigida*, *Pinus inops* (= *P. virginiana*) are the dom inant trees embraces the basin of the French Broad River, the river hills o the Swannanoa and the lower hills in several counties in North Carolina, lying below an elevation of 2800 feet (850 m) above sea level. With these pines ar

1) HARSHBERGER, JOHN W.: Bogs, their Nature and Origin. The Plant World XII: 53—5 March 1909.

2) BUCKHOUT, W. A.: A Bit of wild Nature in Pennsylvania. Garden and Forest V: 314 also PORTER, T. C.: Sketch of the Botany of Pennsylvania. Walling and Gray's Topographic Atla of Pennsylvania 1872: 25—26.

associated *Quercus alba*, *Q. coccinea*, *Q. prinus*, *Castanea dentata*. The ridges and low hills are covered near the Peaks of Otter, Virginia, by *Pinus inops*, *Castanea pumila*, *Quercus marylandica* (= *Q. nigra*), *Oxydendrum arboreum*, *Tephrosia virginiana*, *Spiraea Aruncus* (= *Aruncus silvester*), *Silene virginica*, *Oenothera glauca*, *Galax aphylla*.

The woodland in which *Pinus Strobus* is the dominant coniferous tree is not extensive, but lies in isolated small bodies along the crest, and southern and eastern slopes of the Blue Ridge, or on the low hills on the west. Extensive forests containing this pine occur on the south fork of New River, in the upper valley of the Linville River, in the valley of the French Broad River. This tree is associated with *Quercus alba*, *Q. tinctoria* (= *Q. velutina*), *Q. rubra*, *Q. coccinea*, *Q. Prinus*, *Castanea dentata*, when growing along the crests or flanks of rolling hills, on course, often porous, gravelly loamy soils.

*Deciduous Forest Formation.* The forests of the lower mountains lie between 1500 and 3000 feet (460—915 m) elevation. They occupy the eastern and southern slopes of the Blue Ridge and its outlying spurs and to the westward of the Blue Ridge, they occupy the hill and lower mountain slopes up to about 3000 feet. The same species of oak, named as companions of *P. Strobus* and hickories (*Carya tomentosa* = *Hicoria alba*, *C. amara* = *H. minima* and *C. alba* = *H. ovata*), *Castanea dentata*, *Cornus florida*, are the chief broadleaf trees. These form a story of varying density but never constituting over one-half of the trees. The area in which *Pinus pungens* and *P. rigida* are the important trees embraces the eastern and southern slopes of the Blue Ridge with the outlying spurs from Georgia to Virginia, associated with *Pinus mitis*, *Quercus coccinea*, *Q. Prinus* and *Castanea dentata*. There is no underwood. *Tsuga caroliniana* is confined to the eastern slope of the Blue Ridge, while *Juglans nigra* occupies the deep narrow hollows which indent the eastern slopes and with it are associated *Robinia pseudacacia*, *Liriodendron tulipifera* and *Quercus alba*.

The forests of the higher mountains embrace the woodland lying at an elevation above that of the forests of the lower hills and below 5000 feet. The lower limit of their distribution is about 3000 feet. The forests of the high mountains may be divided into (1) those lying on the crests, and on the slopes facing the south, and (2) those of the north slopes and hollows, and along the bottom lands. The soils of south hill-sides are drier and are thinner than those on slopes with a northerly aspect, and the amount of light and heat is greater than is secured on hillsides with equal, inclinations to the north and the trees are consequently of the light demanding kinds[1]). The trees occurring on the slopes facing the north and in the hollows are: *Tsuga canadensis*, *Fagus americana*, *Castanea dentata*, *Quercus rubra*, *Q. alba*, *Rhododendron maximum*, *Liriodendron tulipifera*, *Fraxinus americana*, *Magno-*

1) PINCHOT, GIFFORD and ASHE, W. W.: Timber Trees and Forests of North Carolina. North Carolina Geological Survey. Bulletin No. 6 (1897): 220.

*lia acuminata*, *Aesculus flava*. The characteristic trees which are to be found on the northern slopes and hollows are: *Tsuga canadensis*, *Rhododendron maximum*, *Betula lenta*, *B. lutea*. On the southern slopes and along the gravelly crests of the hills the growth is less varied being largely composed of *Castanea dentata*, *Quercus alba*, *Q. rubra*, *Q. tinctoria* (= *Q. velutina*) and *Q. Prinus*. The forest on the southern slope is less dense than on northern and the trees are smaller.

We will consider this formation as it occurs in different parts of the southern Appalachian Mountains.

The gorge at the Natural Bridge of Virginia is that of Cedar Creek[1]. In general, the sunlight has full influence on the vegetation of the north bank, while the south bank is so steep that the sunlight, if it reaches the soil at all, does so at an angle, and, consequently, its full effect is lost on the plants of the south and shaded side. The dominant forest trees of the south side of Cedar Creek consist of tulip poplar, Liriodendron tulipifera; sugar maple, Acer saccharum; hemlock, Tsuga canadensis; walnut, Juglans nigra; Hicoria sp.; the beech, Fagus americana, scarlet oak, Quercus coccinea; red elm, Ulmus fulva; ash, Fraxinus sp.; chestnut oak, Quercus Prinus; arbor vitae, Thuja occidentalis; red oak, Quercus rubra; linden, Tilia americana. As secondary trees, somewhat tolerant of the shade, are found red mulberry, Morus rubra; witch hazel, Hamamelis virginiana; Judas tree, Cercis canadensis; sassafras, Sassafras officinale. Forming a third and lower stratum of vegetation, the writer noted the dockmackie, Viburnum acerifolium, Viburnum pubescens, and Sassafras. Near the bridge and extending up stream on the south side for a distance of a hundred yards is a tumbled mass of limestone rocks, which the writer believes may be looked upon as part of the fallen-in roof of the cavern which geologists tell us existed here. Among these rocks, which are moss grown and lichen-covered, the following herbs live in the shade of the dominant forest trees: yellow puccoon, Hydrastis canadensis; wood nettle, Laportea canadensis; wild ginger, Asarum virginicum; Indian turnip, Arisaema triphyllum; walking fern, Camptosorus rhizophyllus; Christmas fern, Polystichum (Aspidium) acrostichoides; may apple, Podophyllum peltatum (not abundant); blood root, Sanguinaria canadensis; Viola scabriuscula; Viola canadensis, and Euphorbia commutata. Two funguses grow on the rotten logs here, viz., Peziza coccinea and Coprinus comatus. The summit of the south hill along the flatter levels above supports the white pine, Pinus Strobus, which is scattered throughout the deciduous forest on this side of the canyon. The sycamore, Platanus occidentalis; the white pine, Pinus Strobus; the butternut, Juglans cinerea; the water beech, Carpinus caroliniana are trees found along and on both sides of the stream.

The dominant trees of the north or sunny bank are the swamp white oak, Quercus bicolor (= Q. platanoides); the tulip poplar, Liriodendron tulipifera; the hemlock, Tsuga canadensis; the sugar maple, Acer saccharum; the black walnut, Juglans nigra; the beech, Fagus americana (= F. ferruginea); the hackberry, Celtis occidentalis; the chestnut oak, Quercus Prinus, and the arbor vitae, Thuja occidentalis (nearly three feet in diameter).

The trees of the slopes of White Top Mountain are *Acer saccharum* (in groves), *Acer rubrum*, *Juglans nigra*, *Castanea dentata*, *Liriodendron tulipifera*, *Quercus Prinus*, *Q. alba*, *Q. rubra*, *Fraxinus americana*, *Tilia heterophylla*, *T. americana*, *Fagus americana*, *Magnolia Fraseri*, *M. acuminata* with *Clethra acuminata*, *Oxydendrum arboreum*, *Rhododendrum calendulaceum*, on boulders *Rubus Millspaughii*. In the deep woods on the slopes of White

1) HARSHBERGER, J. W.: The Forest at the Natural Bridge of Virginia. Forest Leaves IX 42—44. June 1903.

Top Mountain occur: *Listera convallarioides*, *Habenaria orbiculata*, *H. psycodes*, *Diphylleia cymosa* (in great masses), *Trautvetteria palmata* [1]).

Along the valley of the Swannanoa River grow magnificent oaks *Quercus falcata* (= *Q. digitata*), *Q. imbricaria* with *Leucothoë Catesbaei*, *Aconitum uncinatum*, etc. The valley of the North Fork of the Swannanoa River is occupied by an arboreal vegetation, composed of *Castanea dentata*, *Liriodendron*, *Fagus*, *Quercus alba*, *Q. rubra*, *Magnolia acuminata*, *Juglans cinerea*, *Quercus coccinea*, *Q. phellos*, *Acer saccharum*, *Betula lenta* (Castanea-Acer-Quercus Facies), *Rhododendron maximum* forms a dense jungle along the borders of streams (Rhododendron Association).

These dominant trees are found somewhat back from the streams, while near the streams, with their roots in the water, or where the lower parts of their trunks may be submerged during heavy rains, grow *Platanus occidentalis*, *Tsuga canadensis*, *Betula lenta* (Tsuga Facies). This facies constitutes the hemlock bottom type of the foresters which covers the broad, nearly level bottom lands of the main valleys, on the deep, fresh loamy clay and clay loam soils, and follows the narrow valleys of the smaller streams up the slopes of the mountains. It extends over the northwest slope of Grandfather Mountain nearly to the top.

Tsuga canadensis is the dominant tree and with it are admixed Betula lutea, Fagus americana, Acer rubrum and Castanea dentata (= C. americana) with an undergrowth almost exclusively of Rhododendron maximum. [Hemlock Formation.] At the Natural Bridge of Virginia in the alluvial soil of the gorge is found a pure hemlock forest. Beneath the dense shade of the hemlock tree, which is here dominant, the botanist finds on the ground Mitchella repens, the partridge berry, which here, as elsewhere, is tolerant of the dense shade cast by the crown of the hemlock trees. Occasionally associated with the hemlocks, as secondary species, because they are tolerant of shade, the forester finds the beech, Fagus americana, the dockmackie, Viburnum acerifolium, and the witch hazel, Hamamelis virginiana.

Elsewhere, as at Iron Mountain (3000 feet, 915 m) among the hemlocks, Tsuga canadensis, are small groves Pinus Strobus (Strobus Facies) and thickets of Rhododendron catawhiense (found at a much higher elevation in North Carolina), Acer spicatum, A. pennsylvanicum, Rubus odoratus and in gloomy ravines Kalmia latifolia and Rhododendron maximum. Here in the deep shade grow Asarum canadense, Asarum virginicum, Polygala pauciflora, Waldsteinia fragarioides.

The shrubs of the forest elsewhere in southwest Virginia are Cercis canadensis, Cornus florida, C. alternifolia, Staphylea trifolia, Physocarpus opulifolius, Robinia hispida, Berberis canadensis all of which flower in May, while in the dense woods are found Dirca palustris, Lindera Benzoin, Cornus sericea, Rhododendron calendulaceum (= Azalea lutea), Halesia tetraptera. Smilax hispida overgrows shrubs in the woods while Dioscorea villosa and Smilax herbacea grow in close association. Iris cristata inhabits wooded hillsides forming great masses with Jeffersonia diphylla in the deepest, shadiest ravines.

The woods on the southeast slopes of Iron Mountain are characterized by Actaea alba, Caulophyllum thalictroides, Diphylleia cymosa, Zizia Bebbii, Thaspium barbinode, Menziesia globularis, Vaccinium corymbosum var. pallidum, Aristolochia sipho. Other woodland herbs are

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1) Consult VAIL, ANNA M.: Notes on the Flora of Smythe Co., Va. Garden & Forest V: 364, 388, 424, 437: The Alleghenies of Va. in June Garden & Forest III: 367, 391; SHRIVER, HOWARD: Some notes from Wytheville, Va. Botanical Gazette I: 26; KEARNEY, T. H.: Notes on Flora of S. E. Kentucky: Bulletin Torrey Botanical Club XX: 474.

Viola cucullata, Houstonia serpyllifolia, Phlox reptans, Podophyllum peltatum, Polygonatum giganteum. Uvularia perfoliata, U. sessilifolia, Orchis spectabilis, Cypripedium parviflorum, C. acaule, Liparis liliifolia, Aplectrum hiemale, Silene virginica, Trautvetteria palmata (= T. carolinensis), Thalictrum clavatum, Zanthorhiza apiifolia, Hydrastis canadensis, Dicentra cucullaria, Claytonia virginica, Geranium maculatum, Impatiens pallida, I. fulva, Galax aphylla, Obolaria virginica.

Surrounding Salt Pond, near Salt Pond Mountain, are thickets of Rhododendron maximum and Kalmia latifolia, while back in the woods on the ground are Viola pubescens, V. striata, V. rotundifolia, V. sagittata, V. canadensis, and in swampy places Tradescantia virginica, Parnassia asarifolia, Trautvetteria palmata, Veratrum viride. The damp borders of the rivers are characterized by Cladrastis tinctoria (= C. lutea) and by such herbs as Phacelia Purshii, Viola striata, V. rostrata. Solea concolor, Dianthera americana, Spiranthes latifolia, Habenaria bracteata, Carex stenolepis (= C. Frankii).

Such rare plants as Boykinia aconitifolia, Asplenium montanum grow in the woods on the slopes of White Top Mountain. The gorge of Doe River in east Tennessee is noted for a number of rare plants: Adlumia cirrhosa, Dicentra eximia, Campanula divaricata, (on shelf-like ledges) with Corydalis glauca, Cystopteris fragilis, Nephrodium (Aspidium) marginale, Aralia spinosa.

*Rock Cliff Formation.* The clefts of the rocky ridges in southwestern Virginia are tenanted by *Hepatica acutiloba*, *Polypodium incanum*, *Pellaea atropurpurea*, *Asplenium parvulum*, *A. ruta-muraria*, while the cliffs are occupied by *Cystopteris bulbifera* and *Camptosorus rhizophyllus*. Bald Knob in Virginia is the end of a long rocky ridge and is one vast flower garden because here occur: *Saxifraga leucanthemifolia*, *Asplenium montanum*, *Heuchera villosa*, *Convallaria majalis*, *Anemone trifolia*, *A. nemorosa* (= *A. quinquefolia*), *Clintonia umbellata*, *C. borealis*, *Sedum ternatum* (great mats on rocks), *Trillium grandiflorum*, *Chamaelirium luteum*, *Gillenia trifoliata* overshadowed by such shrubs as *Rhododendron calendulaceum*, *R. nudiflorum*, *Ribes cynosbati*, *R. rotundifolium*, *Ilex monticola*.

The limestone cliffs along New River are tenanted by Pachystima Canbyi, Berberis canadensis, Rhus canadensis, Camptosorus rhizophyllus, Asplenium ruta-muraria, A. parvulum, A. trichomanes, Arabis lyrata, Draba ramosissima, Clematis (Viorna) viorna, Arenaria Michauxii, Pellaea atropurpurea. The ledges of exposed sandstone in southeast Kentucky support Corydalis glauca (= Capnoides sempervirens), Lechea racemulosa, Gnaphalium Helleri, Eupatorium pubescens, Agrostis intermedia, Panicum commutatum var. latifolium while in the shaded situations grow Heuchera Rugelii, Goodyera pubescens, Liparis liliifolia, Asplenium montanum and on the bluffs of deep gorges Rubus odoratus, Stuartia pentagyna, Scutellaria saxatilis, Aster prenanthoides. The surface of dry slate exposure along streams is occupied by Phyllanthus carolinensis, Aster dumosus. On the ledges of White Top Mountain are Dicentra eximia and Arabis lyrata, Rhododendron calendulaceum (= Azalea lutea), Amianthium muscaetoxicum. On dry cliffs along the French Broad River are Pentstemon Smallii, Philadelphus hirsutus.

The highest cliffs of the Chilhowee range in east Tennessee at an elevation of about 2500 feet along vertical cliffs of Potsdam sandstone are characterized by thickets of *Chionanthus virginica*, *Cheilanthes tomentosa* (in the crevices), *Ch. vestita*, and some larger species of *Asplenium*, *Polypodium Phegopteris* and *Aspidium* abound [1]).

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1) GATTINGER, AUGUSTIN: The Flora of Tennessee. 1901: 15.

On the limestone ledges of Lookout Mountain are *Gatesia laetevirens*, *Callicarpa americana*, *Triosteum perfoliatum*, *Silphium brachiatum*. — On the exposed cliffs forming the escarpment of Cheehawhaw Mountain, *Lonicera flava* trails over the rocks associated with *Rubus canadensis*, *Smilax rotundifolia*, *Vitis bicolor*, *Prunus injucunda*, *Robinia hispida*, *Rosa humilis*, with *Cheilanthes tomentosa*, *Nephrodium marginale*, while *Stenophyllus capillaris* and *Talinum teretifolium* cover the flat expanses of the rocks bare of any other vegetation. *Silene stellata*, *Anychia dichotoma* prefer the shaded rocky shelves [1]).

Many ferns peculiar to the Cumberland mountain plateau (Sand mountain, etc.) take root in the chinks of the bare rocks. Such are Cheilanthes tomentosa, Ch. vestita, Ch. alabamensis, Pellaea atropurpurea, Asplenium montanum, A. ruta-muraria, A. pinnatifidum associated with Silene rotundifolia, S. caroliniana (= S. pennsylvanica). Saxifraga virginica, Arenaria stricta, Senecio obovatus. Under shelving rocks in the so called »rock houses« in the Cumberland mountain plateau area of Alabama, the gloomy recesses are occupied by a rare little fern Trichomanes Petersii, while T. radicans is a frequent inhabitant of such situation as also Asplenium Trichomanes, a liverwort (Dumortiera), Agrostis perennans and Heuchera Rugelii.

## 2. The Forests at higher elevations.

The dominant forest trees belonging to the Castanea-Quercus-Acer Facies found on the slopes of Grandfather Mountain from an elevation of 3800 to 4500 feet (1150—1370 m) are *Castanea*, *Quercus coccinea*, *Q. phellos*, *Q. bicolor*, *Q. alba*, *Fagus*, *Betula lutea*, *Magnolia acuminata*, *Liriodendron*, *Robinia*, *Acer rubrum*, *Nyssa* etc., while as secondary species, usually found beneath the dominant ones, can be mentioned *Prunus pennsylvanica*, *Rhododendron maximum*, *Hamamelis* and *Kalmia latifolia*. On this mountain the woody plants of less obvious importance, which may be considered to form a still lower story, are *Andromeda floribunda*, *Sassafras* and *Robinia hispida*, the last forming an almost pure growth (Robinia hispida Association). This facies constitutes the chestnut slope type of the foresters [2]) and occupies the southeast, south, southwest and west exposures and the tops of the lower mountains. It extends on Grandfather and Grandmother to 4600 feet elevation. The chestnut tree (*Castanea*) forms 45 per cent of the stand.

The herbaceous plants between the trees are Galax aphylla, Medeola virginiana, Diodia virginiana, Silene virginica, Pedicularis canadensis, Asclepias exaltata, Lysimachia quadrifolia, Osmunda cinnamomea, Nephrodium (Dryopteris) marginale, Pteris aquilina, Uvularia puberula, Prunella vulgaris, Podophyllum peltatum, Ceanothus americanus, Monarda didyma, Chrysanthemum leucanthemum, Cerastium viscosum, Trifolium repens, and near cultivation Nepeta glechoma (= Glechoma hederacea).

Acer saccharum Facies. This occurs typically on the northwestern slope of Grandfather Mountain, on the watersheds of the Linville and Watauga rivers and on the Elk Creek watershed. It constitutes the sugar maple slope type of forest in which Fagus americana, Acer

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1) Mohr, Charles: Plant Life of Alabama, 61—63.

2) Reed, Franklin W.: Report on an Examination of a forest Tract in western North Carolina. U. S. Bureau of Forestry Bulletin 60, p. 12 (1905).

saccharum, Tilia americana, Betula lutea, Tsuga canadensis, Aesculus flava, Fraxinus americana and Magnolia acuminata are the prominent trees. It approximates in constitution the Aesculus-Acer-Betula-Facies below. Numerically Fagus predominates but the trees of Acer saccharum are larger and more uniformly distributed and in general give character to the type. The undergrowth consists of Acer pennsylvanicum, Viburnum lantanoides, Mitchella repens, Oxalis acetosella, ferns and mosses.

The forest on the northern slopes of Roan Mountain is similar to those on the Swannanoa River and Grandfather Mountain. It comprises the *Mixed deciduous formation* with the Castanea-Quercus-Acer Facies, as well characterized as at the places described above[1]), consisting of immense trees of *Castanea, Liriodendron, Acer, Tilia, Aesculus flava, Fagus,* while distributed through these woods at different elevations are *Adiantum pedatum, Asplenium thelypteroides, Nephrodium spinulosum* var. *intermedium, N. noveboracense, N. Goldieanum, N. (Phegopteris) hexagonopterum, Botrychium virginianum.*

Reaching an elevation of 4500 feet (1370 m) on the Black Mountain range, *Picea nigra* (= *P. mariana*) is found sparingly in the forest, as outposts of the main coniferous forest above. Associated in such places, the botanist finds as indication of a rise in altitude *Diphylleia cymosa, Veratrum viride, Rhododendron calendulaceum, Thalictrum clavatum,* and an abundance of *Houstonia serpyllifolia.* As he approaches "Half Way" (5200 feet, 1585 m) the forest of deciduous trees become more open by the lowering of the crown of the dominant trees (Aesculus-Acer-Betula Facies) an index of altitude.

A somewhat different assemblage of species is found on Grandfather Mountain at an elevation above 4500 feet (1370 m). The dominant trees are *Quercus rubra, Picea nigra, Acer saccharum, Prunus pennsylvanicum* on the drier soils, and *Tsuga canadensis* ascending along the water courses to about 4700 feet (1430 m). The secondary species are *Acer pennsylvanicum, Sorbus americana, Viburnum lantanoides* and *Acer spicatum.* Occuring as undershrubs are *Rhododendron calendulaceum* and *Ribes rotundifolium.*

On Roan Mountain the first indication of a rise in altitude is furnished by *Acer spicatum,* and then by *Acer pennsylvanicum,* which does not descend quite as low as the mountain maple. *Viburnum lantanoides* occurs in great abundance when at an altitude of 4500 feet (1370 m) is reached. *Houstonia serpyllifolia* carpets the ground in many places, while in damp places *Diphylleia cymosa* forms masses beneath the shade of the dominant forest trees, and in rivulets is found *Saxifraga erosa.*

The herbaceous plants of the forest floor at this elevation are Caulophyllum thalictroides, Actaea alba, Cimicifuga racemosa, Tiarella cordifolia, Sanguinaria canadensis, Podophyllum peltatum, Circaea alpina, Solidago caesia, Eupatorium ageratoides, Gentiana quinqueflora, Rudbeckia laciniata, R. triloba var. rupestris, Habenaria (Blephariglottis) peramoena, Cacalia atriplicifolia, Habenaria (Lysias) orbiculata, Chelone Lyoni, and Polystichum acrostichoides. A few straggling

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1) HARSHBERGER, JOHN W.: An ecologic study of the Flora of mountainous North Carolina Botanical Gazette XXXVI: 241—258; 368—383. Oct. and Nov. 1903.

black spruce trees descend the mountain side and mingle with Betula lutea and B. lenta. Fagus americana, which becomes dwarfed at the edge of the coniferous belt, is associated with birches in this tension belt (Betula-Fagus Facies).

Aesculus flava, which occurs at the upper edge of the tension belt, ascends the mountain into Carver's Gap, where it forms an almost pure stand of gnarled trees (Aesculus Facies).

The Balsam Mountains are more heavily timbered than other cross ranges. On both northern and southern slopes there are deep, cool hollows, or coves with fertile soil producing vigorous growth. The woods consist of hardwood trees associated with hemlock and spruce. On the northern slopes such trees as *Tilia americana*, *Aesculus flava*, *Liriodendron* dominate while the proportion of oaks and *Castanea dentata* is smaller. *Tsuga canadensis* is associated with these in the deep hollows, while *Picea nigra* crowns the summits of the northern slopes. On the southern slopes oaks and chestnut form the larger proportion of the timber and there are less of the lighter woods and hemlock and almost no spruce [1]).

The summit of Big Frog Mountain is covered by *Castanea*, *Quercus rubra*, *Betula lutea*, *Sorbus americana*, *Prunus pennsylvanica* and *virginiana*; as shrubs occur *Ribes*, *Vaccinium*, *Rhododendron arborescens*, *Stuartia*, *Ilex*, *Salix humilis*, *Rubus odoratus* and on the ground *Gaultheria procumbens*.

The forests of the Great Smoky Mountains are chiefly of hardwoods with a large amount of coniferous growth on the higher summits and in the deep, cool hollows. On the drier slopes, and especially on the south slopes, oaks and chestnut form the predominant growth with some *Pinus rigida* and *Pinus mitis* on the ridges. The forest in the hollows consists of *Tilia heterophylla* and *Aesculus flava*, associated with species of oak and chestnut.

### 3. Forests and Subalpine Formations of the Southern End of the Appalachians.

The Cumberland Mountains stretch from Tennessee to northern Alabama. The flora corresponds in general with that of the higher mountains of the adjoining states which enter Alabama at an altitude not exceeding 2000 feet. In the Lookout mountain territory the large preponderancy of deciduous leaved trees, the almost entire absence of magnolias and coniferous trees in general, particularly of pines of a decided southern range is noteworthy [2]).

Lookout Mountain near Chattanooga may be taken as the type. The summit and slopes was originally covered with a forest consisting of Quercus Prinus, Q. rubra, Q. alba, Q. obtusiloba, Q. nigra, Betula lutea, Gleditschia triacanthos, Robinia pseudacacia, Carya microcarpa (= Hicoria odorata), Pinus taeda, P. mitis, P. inops (= P. virginiana) reaches its best development on

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1) See Message from the President of the United States transmitting a Report of the Secretary of Agriculture in relation to forests, rivers, and mountains of the southern Appalachian region. Senate Document 84: 210. Washington, 1902.

2) GATTINGER, AUGUSTIN: The Flora of Tennessee 1901: 14—19.

rocky benches and declivities with a scanty soil. The shrubs are Robinia hispida, Diervilla rivularis, Ilex mollis, Stuartia pentagyna, Hydrangea radiata, and Buckleya distichophylla (but very rare) Nemopanthes canadensis and Dirca palustris in swamps[1]. Under the umbrageous cover of the high forest on the upper flanks of this mountain, in deep soil, rich in humus are Ligusticum canadense, Angelica hirsuta, Thaspium pinnatifidum, T. barbinode, Pimpinella integerrima, Zizia serrata, Polygonatum commutatum, Oxalis recurva, Trillium stylosum (of the southern Appalachian ranges), Polygonatum giganteum, Anemone nemorosa (A. quinquefolia), Stellaria pubera, Galium latifolium, Asclepias quadrifolia, Trillium erythrocarpum, Disporum lanuginosum, Uvularia grandiflora, U. perfoliata and Cypripedium acaule found in more open boggy places.

On the brow of Lookout Mountain, and particularly along the banks of Little River, there occurs a strong mingling of types that are at home in the Alleghanian area of the adjoining states and of North Carolina with plants of the lower ranges giving rise to a varied flora. Here occurs together with *Viburnum*, *Diervilla*, *Vaccinium* at 2000 feet elevation *Rhododendron catawbiense*. Ferns line the banks of Little River the rich soil shaded by rocks: *Asplenium Bradleyi*, *A. parvulum*, *A. trichomanes*, *Athyrium filix-foemina*, *Dennstaedtia punctilobula*, *Asplenium montanum*, *A. pinnatifidum*, *Nephrodium marginale*, and elsewhere in the Cumberland Mountains, which excel the Alleghanies in a greater variety of ferns, are *Lygodium palmatum*, *Scolopendrium*, *Trichomanes*, *Asplenium viride*, *Adiantum capillus-veneris*. — *Sarracenia Catesbaei*[2]), occurring from Alabama west to eastern Texas in the coastal belt, *Isoetes Engelmanni* var. *valida* are paludial plants founds on the banks of Little River near De Soto Falls. *Carex virescens*, *Tiarella cordifolia*, *Asclepias quadrifolia*, *Asarum macranthum* inhabit the rocky dells and more or less open copses while *Arenaria brevifolia* forms an association with *Sedum ternatum*, *Talinum teretifolium* growing out from the crevices of rocks covered with cushions of mosses (*Grimmia*, *Hedwigia*). — On rocky flats of the tableland, where neither shrub nor tree is able to gain a foothold, this latter association with *Opuntia Rafinesquii* fill every hollow and crevice. Wherever a rich deep soil covers the heights in the metamorphic region of Alabama, the slopes of the mountains and the lower hills, deciduous trees predominate, though rarely the short-leaf pine *Pinus mitis* (= *P. echinata*) makes its appearance. Notable is the scarcity of *Liriodendron*, *Magnolia acuminata*, *Carya alba* (= *Hicoria tomentosa*) etc.

The highest summits are frequently watered by springs, giving rise to grassy swales and lively brooklets. Here prevail, in the damp soil: Solidago odora var. inodora, S. arguta, Angelica villosa, Osmunda cinnamomea, Scleria caroliniana, Habenaria ciliaris, while the banks of these brooks are shaded by Kalmia latifolia, Ilex opaca, Rhododendron arborescens, R. nudiflorum, Calycanthus floridus, Ilex monticola, Amelanchier canadensis, Hydrangea arborescens var. cordata, Azalea viscosa var. glauca, Zanthorhiza apiifolia and Betula lutea here at its southern limit reduced to a small shrub.

The following plants of northern range find on the metamorphic highlands of Alabama their southern limit, viz.,

1) MOHR, CHARLES: Plant Life of Alabama 77—79.

2) MACFARLANE, J. M.: The History, Structure and Distribution of Sarracenia Catesbaei Ell. Contributions from the Botanical Laboratory of the University of Pennsylvania. II: 426—434.

Uvularia perfoliata L.
» (Oakesia) sessilifolia L.
Smilacina (Vagnera) racemosa L.
Trillium stylosum Nutt.
Polygonatum biflorum Walt.
Smilax echirrhata Engelm.
Habenaria (Blephariglottis) lacera Michx.
Darbya umbellulata Gray (= Nestronia umbellula Raf.).
Asarum virginicum L.
Sanicula marilandica L.
» trifoliata Bicknell.
Philadelphus grandiflorus Willd.
Hydrangea arborescens L.
Chimaphila umbellata L.
Vaccinium vacillans Kalm.
Houstonia tenuifolia Nutt.
» longifolia Gaertn.
Solidago amplexicaulis T. & G.
Aster Shortii Lindl.
» sagittaefolius Wedemeyer.
Sericocarpus conyzoides Nees (= S. asteroides [L.).
Silphium compositum Michx.
Hieracium venosum L.

*Barren Forest Formation.* On the extremely rugged area which forms the watershed between the Coosa and Tallapoosa rivers, the steep hills of silicious cherts and obdurate sandstone which reach scarcely an elevation of 1000 or 1200 feet, support an inferior growth of *Quercus Prinus*, *Q. marylandica*, *Q. tinctoria* (= *Q. velutina*), *Q. falcata* (= *Q. digitata*), *Q. obtusiloba* (= *Q. minor*), *Carya porcina* (= *Hicoria glabra*) and *Pinus palustris*, scantily interspersed between the trees and stunted specimens of *Sassafras*, *Rhus copallina* and *glabra*.

The flats of the Coosa Valley are covered with a low forest of dwarfed trees of *Quercus marylandica* and *obtusiloba*, scarcely over 20 feet high with equally stunted *Pinus taeda* and with a few specimens of *Pinus mitis* and *P. inops* scattered among them, while the association of *Crataegus crus-galli*, *C. spathulata*, *C. apiifolia* with the trees form an impenetrable thicket in which also grows *Nyssa multiflora* supporting *Smilax bona-nox* and *laurifolia*.

The extreme southern spurs of the western Alleghanian ranges including the Cumberland Mountains and all of the strata of the lower coal measures and underlying subcarboniferous rocks were in Alabama originally covered by an uninterrupted forest of a varied growth of hardwood trees and conifers. On the bread expanse of the tablelands above 900 or 1000 feet *Quercus Prinus* largely prevails associated with other species of oak; also with *Castanea*, *Carya tomentosa* (= *Hicoria alba*) and *C. porcina* = (*H. glabra*), *Nyssa sylvatica* and the smaller *Oxydendrum arboreum*.

The tableland of Sand Mountain is covered by an almost unbroken forest rather open in character and it presents a varied growth of deciduous trees interspersed with *Pinus mitis* and *P. taeda*. The largest part of the area is occupied by a forest consisting of oaks, chestnut and hickory with *Liriodendron*. *Pinus mitis* is found more or less frequently scattered among the hardwood trees, wherever a sandy or drier soil prevails. *Pinus taeda* prefers a damp or wet soil. With the improvement of the soil *Quercus alba*, *Q. Prinus*, *Q. obtusiloba* became more prominent in the forest growth [1]).

1) Mohr, Charles: Report on the Forests of Sand Mountain. The Forester IV: 211—215 Oct. 1898.

Where the sandstone gives way to clayey soils, erosion is active and deep valleys are formed in the Sand mountain plateau in Alabama. The following trees are found in such secluded valleys, viz, *Quercus Michauxii*, *Fagus americana*, *Ulmus americana*, *Juglans cinerea*, *Tilia americana*, *T. heterophylla*, *Magnolia umbrella* (= *M. tripetala*), *M. acuminata*, *M. macrophylla*. Rocky defiles or gorges are shaded by *Tsuga*, *Betula lenta*, *Ilex*, *Vaccinium virgatum* associated with *Rhododendron catawbiense*, *Oxydendrum arboreum*, *Hydrangea quercifolia*, *arborescens*, *radiata* and *cinerea*, *Ribes* and *Halesia*. At the base of the mountain on the limestone formation is found the rare *Neviusia alabamensis* associated with *Staphylea trifolia*, *Tilia heterophylla*, *Aristolochia tomentosa*, *Calycocarpum Lyonii*, *Menispermum canadense*, *Solea concolor* and *Urtica chamaedryoides*.

*Coniferous Forest Formation.* The coniferous forest appears on the slopes of the Black Mountain Range at about 5200 feet (1585 m). The dominant tree of this formation is *Picea nigra* (= *P. mariana*) associated with *Abies Fraseri*. Intermingled with these two coniferous trees, but nowhere making a pure growth, are *Acer spicatum*, *Betula lutea*, *Aesculus flava*, *Sorbus americana*, and *Crataegus* sp. (Sorbus-Acer Facies). The trees are large and rugged, and clothed even to the topmost branches with dense coats of moss. Mosses and lichens cover the ground as with a dense mat a foot or more thick. The trunks of fallen trees are buried from sight by a living mound of green, set with flowers and ferns.

The mosses and lichens collected by the writer, which form the Polytrichum-Hypnum Association on Potato Top and Clingmans Dome comprise the following: Polytrichum gracile, Sematophyllum delicatulum, Hypnum fertile, Hylocomium proliferum. Bazzania trilobata, Hylocomium triquetrum, Dicranum fuscescens, Hypnum reptile, Polytrichum ohioense, and Stereocaulon coralloides. Associated with these mosses are herbaceous plants and ferns, viz., Oxalis, acetosella, Viola blanda, Lycopodium lucidulum, and Nephrodium (Aspidium) spinulosum var. intermedium. Houstonia serpyllifolia is also abundant. The rocks support in sunny places a Sedum-Carex Association of Sedum telephioides, Carex rosea var. radiata, Saxifraga leucanthemifolia (= S. Michauxii) and Krigia montana.

The green hellebore is found wherever the timber is more open and in extensive patches many square feet in area (Veratrum Association). The same association of species extends to the tops of the several mountains composing the Black Mountain Range. The plants of the Sorbus-Acer Facies are met with in this forest belt with occasional bushes of *Vaccinium erythrocarpum* and *Menziesia globularis*. Many seedling spruces are providing a natural regeneration of the forest. As a secondary but important element of this belt at high elevations, is the Rhododendron catawbiense Association, beneath which as herbaceous associates are found *Viola blanda*, *Trillium erectum*, and *Clintonia borealis*. The natural meadows on this range of mountains, surrounded by the forest of balsam and black spruce trees, are composed of a Carex-Poa Association, viz.: *Carex intumescens*, *C. scoparia*, *C. brunnescens* var. *gracilior*, *C. tenuis*, with *Poa pratensis*, *P. alsodes*, *Agrostis alba*, and *Juncus effusus*. (Carex-Poa Association).

The coniferous forest extends to the summit of Mount Mitchell 6711 feet (2045 m) without any indication of subalpine or alpine conditions. Wind-tossed specimens of *Picea nigra* and *Abies Fraseri* (Picea-Abies-Prunus Facies), are seen, intermixed with *Betula lutea* and *Prunus pennsylvanica.* Huge rocks and bowlders project from the rounded dome. *Menziesia globularis*, *Ribes prostratum*, *Sorbus americana* are common. *Rhododendron catawbiense* grows within a few feet of the Mitchell monument. The herbaceous plants of the summit are *Streptopus roseus*, *Scirpus caespitosus*, *Carex brunnescens*, *Houstonia serpyllifolia*, *Rumex acetosella*, *Trifolium repens*, *Athyrium filix-foemina*, *Saxifraga Michauxii* in the crevices of the rocks, and *Clintonia borealis.* None of these herbs are true alpines.

Mosses are found on the trunks of trees and on the rocks, the following being noted[1]): *Ulota crispa*, *Bryum nutans*, *Sematophyllum delicatulum*, *Hylocomium proliferum*, *Polytrichum gracile*, *Hypnum Schreberi* (Polytrichum-Hypnum Association).

The coniferous forest on Grandfather Mountain consists essentially of the same arborescent species, viz., black spruce and balsam. Associated with these are *Viburnum lantanoides*, *Vaccinium stamineum*, *Acer spicatum*, and *Rhododendron catawbiense.* *Polypodium vulgare* grows in masses, associated with *Galax aphylla*, *Oxalis acetosella*, *Thalictrum clavatum*, *Maianthemum canadense* and *Clintonia borealis.*

The forest of cone bearers on the higher elevations of Roan Mountain consists of *Picea nigra* and *Abies Fraseri* as the dominant trees. Intermixed with these, but never forming pure growths, occur *Aesculus flava*, *Sorbus americana*, *Fagus americana* in a dwarfed form, and as a third lower story, *Ribes rotundifolium*, *Cornus alternifolia*, and *Alnus viridis.*

An untouched virgin forest on the argillaceous slates of Big Frog Mountain was found to consist of *Pinus Strobus*, *P. mitis* and in low and sandy spots *Pinus inops*, while at the foot of ridges or vertical precipices where deep beds of mold accumulate grows *Tsuga canadensis* and beneath in the mossy cushions, *Houstonia*, *Circaea alpina*, *Viola canadensis* and *pubescens*, *Mitella diphylla*, *Oxalis acetosella.*

*Lower Coniferous Forests.* The eastern spurs of the Alleghanies enter the state of Alabama at its eastern boundary and are composed of metamorphic crystalline rocks skirted by the oldest sedimentary strata. Forests of long-leaf pine *Pinus palustris* characterize this mountain region, covering the arid rocky ridges to an elevation of 2000 feet. These pine forests are open and almost entirely bare of undergrowth. At its vertical limit the pine is suddenly replaced by oak, chestnut and *Carya porcina* (= *Hicoria glabra*).

The following herbs are found here: Tephrosia virginiana, T. spicata, Lespedeza hirta, L. repens, Eupatorium album, E. aromaticum, Solidago odora, Sericocarpus tortifolius, Gaylussacia

1) The identification of the mosses I owe to Mrs. ELIZABETH G. BRITTON, of the New York Botanical Garden.

dumosa, Vaccinium stamineum. The pine-clad slopes of Cheehawhaw Mountains, the Blue Mountains are covered sparingly on the steep declines with coarse grasses Andropogon furcatus, A. scoparius, Erianthus alopecuroides, Lespedeza Nuttallii, L. frutescens, L. virginica, L. hirta, L. capitata, Amorpha virgata, Phaseolus perennis (= P. polystachyus), Cassia chamaecrista, Eupatorium album, E. aromaticum, Sericocarpus asteroides, Chrysopsis graminifolia, C. mariana, Aster patens, A. laevis.

The extension of the Cumberland mountain table land into Alabama is characterized by *Pinus mitis* and *P. taeda*, wherever *Quercus Prinus* is absent. These trees reach marketable size (2 feet diameter, 110—120 feet tall). The scrub pine *Pinus inops* (= *P. virginiana*) is found on the poorest soils at an elevation of 1200 feet, but is not frequent. In this rather open forest grow *Vaccinium vacillans* and *stamineum*, *Rhododendron nudiflorum*, *Stuartia pentagyna*, *Ilex monticola*, and its var. *mollis*, *Hydrangea quercifolia*, while along the rocky edges of the smaller streams grow *Vaccinium tenellum*, *Kalmia latifolia*, *Rhododendron arborescens*, *Stuartia virginica* and *Pirus angustifolia* [1]).

*Pine Barren Formations as interjected hill-elements.* Interjected into the plant formations and associations of the southern Appalachian Mountain area, as described above, the phytogeographer finds especially along the French Broad River, in east Tennessee and western North Carolina a strong pine barren element in the flora [2]). In these isolated pine barren areas which cover sandy river bottoms and the dry, sunny lower slopes of the hills are found plants typical of the coastal plain. One such colony is found on the French Broad River below Paint Rock, North Carolina. Where the bluffs recede from the river are sandy tracts covered with a growth of *Pinus rigida* and *P. inops* (= *P. virginiana*). Not a few of the characteristic pine-barren plants inhabits these small areas such as: *Silphium compositum*, *Helianthus atrorubens*, *Andropogon argyraeus*, *Sporobolus asper*, *Erianthus alopecuroides*, *Danthonia sericea*, *Triodia Chapmani*, *etc.* Back from the river, on the lower hills where oaks and chestnuts struggle with the invading pines are *Spiranthes simplex*, *Buchnera americana*, *Lilium carolinianum*, *Eupatorium album*.

Another noteworthy colony of this character occurs at a mean elevation of about 1000 feet in the canyon-like valley of the Hiwassee River in extreme southeastern Tennessee. Here grow most of the above named grasses with *Andropogon Elliottii*, *Paspalum purpurascens*, *Panicum gibbum*, *P. viscidum*, *Erianthus contortus*, *E. brevibarbis*, *Uniola longifolia*; *Baptisia alba*, *Aralia spinosa* and many others.

*Dwarf Tree—Shrub Formation.* The summits of King's and Crowder's Mountains are small and very rugged; that of Crowder's is somewhat larger and less rugged than that of King's Mountain. On ascending the slopes of either

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1) MOHR, CHARLES: Plant Life of Alabama 1901: 70—71.

2) KEARNEY, THOMAS H.: The pine barren Flora in the east Tennessee Mountains. Plant World I: 33—35 Dec. 1897; also the lower austral Element in the Flora of the southern Appalachian Region. Science XII: 830—842, Nov. 30, 1900.

mountain two striking features arrest the eye. They are the prevalence of a very local species which has taken the name of one of the mountains, namely, *Liatris* (*Lacinaria*) *regimontis*, and of the relatively rare fern, *Asplenium Bradleyi*. The main peculiarity in connection with this fern there, is that it does not confine itself to its favorite habitat, namely, overhanging cliffs; but it is, very common on cliffs, on ledges, on and about boulders and in loose soil. The vegetation of the summits is almost exclusively of woody plants, and the shrubby condition of normally large forest trees presents an extraordinary and interesting aspect. The chestnut tree, *Castanea dentata* ranges from three to six feet in height, nevertheless these plants produce an abundance of fruit. *Sassafras officinale*, *Pinus inops*, *Quercus Prinus*, *Diospyros virginiana* and *Oxydendrum arboreum* all appear in the same form and stature. The common sour gum, *Nyssa sylvatica*, in like condition, exists on King's Mountain, and a single shrub of *Ilex opaca* was found on the uppermost cliffs of Crowder's Mountain.

The normally shrubby plants appear more natural. Vaccinium stamineum, Vaccinium vacillans and Quercus ilicifolia (= Q. nana) are common to both peaks, while Kalmia latifolia, Rhododendron catawbiense, Gaylussacia frondosa, Gaylussacia resinosa and Vaccinium arboreum are species apparently confined to the top of King's Mountain. Only two perennials or shrubby herbs, namely Galax aphylla and Paronychia argyrocoma, exist on the summit of King's Mountain, while the summit of Crowder's Mountain is destitute of herbaceous vegetation with the exception of a fern and a few sterile plants of some sedge[1]).

The Dwarf Tree—Shrub Formation exists at the top of Grandfather Mountain and is absent from the coves and ranges of Mount Mitchell and Roan Mountain. The summit of the west peak of Grandfather Mountain for a limited area is bare and presents an alpine aspect, being clothed with lichens, mosses, and dense cushions of *Leiophyllum buxifolium* (Dendrium Association). Several of the plant remind the botanist of the New Jersey pine barrens, viz., *Gaultheria procumbens*, *Xerophyllum asphodeloides*, *Pteris aquilina*, *Kalmia latifolia*.

Zygadenus leimanthoides, Geum radiatum, Paronychia argyrocoma, Uvularia puberula, Clintonia borealis, Carex aestivalis, Amianthium muscaetoxicum, and Solidago spithamea are found in exposed places (thus under edaphic conditions) (Geum-Paronychia Association). Abies Fraseri, Picea nigra, Clethra acuminata, Sorbus americana, Leucothoë recurva, Vaccinium pallidum, Vaccinium erythrocarpum accompany the herbs to the mountain summit, so that this summit may be said not to be entirely treeless, otherwise the plants on it would be classed as an association of the Sub-alpine Treeless Formation.

*Subalpine Treeless Formation.* This formation is encountered typically on Roan Mountain and on other mountain summits in the southern Appalachians that are grassy balds. The "balds" are in the main grassy meadows, but the rounded domes show extensive areas covered by the Rhododendron catawbiense Association, either pure, or associated with *Alnus viridis*

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1) SMALL, JOHN K.: The summit Flora of King's Mountain and Crowder's Mountain, North Carolina. Torreya I: 7. Jan. 1901.

(Alnus Association). The alder covers an adjoining dome of the Roan mountain range, the Elkhorn, with a pure and impenetrable growth three to four feet high. The extent of the rhododendron thickets, for which the mountain is famous, cannot be easily estimated. The bushes may be either rounded, like a hay stack, or they may be spreading at the top[1]).

The summit of Roan Mountain is in the form of a saddle several miles long, being formed of two elevations of about equal height, the culminating peak being 6313 feet (1924 m) in altitude. The component vegetation of the grassy meadows, or "balds" consists of Danthonia compressa (the most abundant grass in dense tufts), Trifolium repens, Rumex acetosella, Potentilla canadensis, Poa compressa, Veronica officinalis, Houstonia serpyllifolia, Carex tenuis, Deschampsia flexuosa, Luzula campestris and Phleum pratense (Carex-Poa Association) with the following grasses noted by LAMSON-SCRIBNER: Agrostis perennans, A. scabra (= A. hiemalis), A. alba, Cinna pendula (= C. latifolia), Brachyelytrum aristatum (= B. erectum), Calamagrostis canadensis, Eatonia pennsylvanica, Glyceria elongata, Poa annua, Poa pratensis, Poa alsodes, Bromus ciliatus, Elymus striatus, Asprella hystrix, Danthonia spicata, Trisetum subspicatum var. molle[2]). Polytrichum commune forms patches, especially about old stumps.

The raised cushions of soil found here are covered by various mosses with *Leiophyllum* (*Dendrium*) *buxifolium*[3]) (Dendrium Association). In or along the dry stony-wash-ways, one finds *Saxifraga leucanthemifolia*, *Potentilla tridentata*, and *Houstonia purpurea.*

The immediate summit of Roan Mountain is characterized by the presence of *Geum radiatum*, *Lycopodium selago*, *Menziesia pilosa*, *Houstonia purpurea*, *Lycopodium lucidulum*, *Ribes rotundifolium*, *Leiophyllum*. *Alnus viridis* clings to the northern slopes, here forming a pure growth on the steeper inclines (Alnus Association), with *Sorbus americana* below it, but associated with *Rhododendron catawbiense* on the upper slopes of the dome.

Among the rocks and on the edges of the precipices are found Paronychia argyrocoma, Heuchera villosa, Sedum rhodiola, S. telephioides, Angelica Curtisii, Campanula divaricata (= C. flexuosa), Carex aestivalis, C. debilis, C. juncea and under the overhanging cliffs the delicate little Saxifraga Careyana.

Crossing Carvers Gap, where Aesculus flava grows (Aesculus Facies), a rocky outcrop is found on the slope of Little Roan Mountain where the writer collected Rhododendron calendulaceum, Oenothera (Kneiffia) fruticosa, Geum geniculatum, Arisaema quinatum and Hypericum graveolens (Kneiffia-Hypericum Association). Here grow according to Chickering[4]), Delphinium exaltatum (= D. urceolatum), Silene virginica, Liatris spicata, Rudbeckia triloba, Castilleia coccinea, Physostegia virginiana, Melanthium virginicum. Alder Bald or Elkhorn, as it is called, is reached from Little Roan Mountain by crossing a smaller wind gap. The slopes of this knob are covered by acres of Alnus viridis (Alnus Association), under which grew formerly the rare Lilium Grayi while the stony places are favorable for the growth of Heuchera villosa, Krigia montana, Cerastium vulgatum, and two alpine species, Potentilla tridentata and Arenaria (Alsine) groenlandica. The latter herb assumes the cespitose character in exposed situations.

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1) Cf. CANNON, W. A.: Field notes on Rhododendron Catawbiense. Torreya 2: 161. 1902.

2) LAMSON-SCRIBNER, F.: The Grasses of Roan Mountain. Botanical Gazette XIV: 253.

3) Cf. SMALL, J. K.: Flora of western North Carolina and contiguous territory. Mem. Torr, Bot. Club 3.

4) CHICKERING, J. W.: A Summer on Roan Mountain. Botanical Gazette V: 144—148; BRITTON, E. G.: Botanical Notes in the Great Valley of Virginia and the southern Alleghanies Bulletin Torrey Botanical Club XIII: 69—76.

## C. Alleghanian—Ozark District.

Geographically this district comprises the Alleghany Plateau west of the Appalachian ranges of mountains, the more level surfaces of Ohio, Indiana, southern Illinois, southwestern Michigan near Lake Michigan, and the Ozark areas of Missouri with an extension southwestward into northwestern Arkansas, Indian Territory, Oklahoma and Texas. Three phytogeographic areas may be recognized, viz., (1) the Lacustrine Area comprising western New York western Pennsylvania, northern Ohio, northern Indiana, southwestern Michigan; (2) the Kentucky-Tennessee Area including southern Ohio, Indiana, Illinois, nearly all of Kentucky, central Tennessee, northern Alabama along the Tennessee River; (3) the Ozark Area, which includes nearly all of Missouri, northwestern Arkansas, Indian Territory, Oklahoma, northern and central Texas. The flora of this district is prevailingly one associated with the dominance of hardwood or deciduous-leaved trees, many species of which form a high forest with secondary trees and shrubs and herbs on the ground beneath.

### a) Lacustrine Area.

This area lies in proximity to and the distribution of its plants is more or less controlled by three great inland lakes: Ontario, Erie and Michigan. For example, the phyto-geographer finds a difference (amounting to 233 species) between the west end of Lake Erie in the neighborhood of Sandusky Bay and the east end near the city of Buffalo.

Thus the following plants found along the south shore of Lake Erie occur farther north than anywhere else in this part of the country[1]). Viola pedatifida, Desmodium (Meibomia) sessilifolium, D. illinoense, Baptisia leucantha, Petalostemon candidus, P. violaceus (= P. purpureus), Ammania coccinea, Rotala ramosior, Eryngium yuccaefolium, Aster Shortii, Boltonia asteroides, Eclipta alba, Helianthus grosseserratus, H. hirsutus, H. mollis, H. occidentalis, Eupatorium altissimum, Kuhnia eupatoroides, Liatris squarrosa, Solidago rupestris, Phacelia Purshii, Gerardia auriculata, Seymeria (Afzelia) macrophylla, Lippia lanceolata, Euphorbia dentata, Populus heterophylla, Smilax bona-nox, Smilax echirrhata, Juncus scirpoides, Carex conjuncta, C. Shortiana, Poa brevifolia, Equisetum laevigatum.

This difference is due to several factors operating; (1) the prevailing southwest winds, which traverse the length of the lake and keep Buffalo cool; (2) the crowding of the winter ice in the spring at the east end of the lake as to prevent navigation three weeks or more after Sandusky is clear; (3) the mean temperature in summer is four degrees lower at Buffalo than at Sandusky due to the position of the lake; (4) the position of the eastern end of Lake Erie is such that it is protected from cold northwest winds of autumn. The influence of these three lakes is shown also in New York where with the central finger lakes of which Cayuga is the largest the climate is greatly ameliorated in their immediate neighborhood. The shore of Lake Erie is

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1) Moseley, E. S.: Climatic Influence of Lake Erie on Vegetation. American Naturalist XXXI: 60 Jan. 1897

famous for its grapes [1]), that of Lake Ontario for its strawberries, peaches and apples. Because of its snug winters, there is rarely any starting of fruit buds by "warm spells", and consequently little danger of loss from spring frosts. The same is true of that part of Michigan on the east shore which is watered by the Muskegon, Grand and Kalamazoo rivers.

## 1. The Water-influenced Formations.

*Lake Formation.* In such ponds as Long Pond in Oswego County, New York, where the water is deep enough, grow *Brasenia peltata* (= *B. purpurea*), *Nuphar advena*, *Nymphaea odorata*, *Potamogeton natans*, and in the shallower waters for example in Oneida Lake are found *Limnanthemum lacunosum*, *Sagittaria graminea*, *Naias flexilis*, *Equisetum limosum*, *Scirpus fluviatilis*, *Nasturtium lacustre* (= *Roripa americana*), while in the quiet water of streams emptying into Oneida Lake in central New York abound such species as *Azolla caroliniana*, *Heteranthera graminea*, *Wolffia columbiana*, *Polygonum emersum*, *Sparganium simplex*, *Comarum*, *Menyanthes*, *Utricularia*, *Saururus cernuus* and several species of *Potamogeton*.

The ends of Irondequoit Bay, Lake Ontario are filled with flags, all of the forms of Typha being present. T. latifolia var. elongata is the most plentiful. Extensive beds of Chara exist. Elodea (Philotria) canadensis; Myriophyllum spicatum and various species of Potamogeton are abundant. Wolffia columbiana and Lemna trisulca, L. minor cover the quiet waters in coves and in open stretches of water. Nymphaea reniformis, Utricularia vulgaris, Vallisneria spiralis are common. Naias marina and Sparganium minimum also occur.

The aquatic plant associations found in the western end of Lake Erie have been described as characteristic for the Lake District (Interlacustrine Area II, B. A. No. 3, see ante). Therefore the reader is referred to former pages of this book (pages 395—398) for an account of this interesting flora, as well, as the papers mentioned below in the footnote [2]).

The flora of Winona or Eagle Lake in northern Indiana [3]) is in centrifugal sequence as follows. (1) In deep water occur Ceratophyllum demersum, Myriophyllum sp., Potamogeton lucens, P. amplifolius, P. pectinatus while the plankton consists of floating confervoid algae, Mougeotia, Rivularia, Clathrocystis, Hydrodictyon, Oedogonium. (2) The plants confined to shallow water are Eleocharis interstincta (= E. equisetoides), E. palustris, E. mutata (= E. quadrangulata), Cladium mariscoides Vallisneria spiralis and Potamogeton natans. (3) The herbs found on shore and extending into the water comprise Scirpus lacustris, Potamogeton fluitans, Nuphar advena, Pontederia cordata while (4) there are plants on shore out of the water, viz., Scirpus americanus, Eleocharis acicularis, Typha latifolia and species of Sagittaria, as also Polygonum amphibium.

*Lake Shore Formation.* The shore of Lake Ontario is usually steep bluffs of "boulder clay" while in some places the Medina sandstone is exposed and in many places the new beach has cut off bays which are filling as marshes The following plants are peculiar to the lake shore: *Ranunculus flammula* subsp. *reptans*, *Cakile americana*, *Polanisia graveolens*, *Lathyrus maritimus*

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1) HEDRICK, V. P.: The Grapes of New York 1908: 73—81.

2) PIETERS, A. J.: The Plants of western Lake Erie. Bull. U. S. Fish Commission 1901: 57—79

3) CLARK, H. WALTON: The Flora of Eagle Lake and Vicinity. Proceedings Indiana Academy Science 1901: 128, 155. See also COULTER, Jr. M.: The Flora of northern Indiana. Botanical Gazette IV: 109—113. Jan. 1879.

*Strophostyles helvola*, *Potentilla supina*, *P. anserina*, *Coreopsis* (*Bidens*) *discoidea*, *Artemisia caudata*, *Polygonella articulata*, *Euphorbia polygonifolia*, *Juncus balticus* var. *littoralis*, *Cyperus Schweinitzii*, *Scirpus Smithii*, *Sporobolus cryptandrus*, *Ammophila arenaria*, *Equisetum variegatum* [1]).

The eastern shore of Oneida Lake in central New York is a broad beach of white sand from 100 to 300 feet in width [2]). It is particularly rich in cyperaceous plants such as, Cyperus rivularis, C. aristatus (= C. inflexus), C. speciosus, C. filiculmis, Fimbristylis autumnalis, Scirpus Smithii, S. pungens (= S. americanus), Hemicarpha micrantha, Eleocharis acicularis, E. intermedia associated with several flowering plants, viz., Lathyrus maritimus, Polygonella articulata. The occasional sandy beaches of the southern shore present about the same plants as those of the eastern shore. At Lewis Point grow in addition Equisetum littorale, E. hyemale var. intermedium, Dryopteris simulata, Botrychium obliquum var. oneidense (at high-water mark) Ophioglossum vulgatum nearer the water. Onondaga Lake shows a number of maritime species. At this lake several salt springs are found but it lacks however the extensive sandy beaches of Oneida Lake. The east shore of Lake Erie at Buffalo [3]) is characterized by Cakile americana, Lathyrus maritimus, Euphorbia polygonifolia, Triodia purpurea, Hudsonia tomentosa and several other lake shore plants not known inland or on the Atlantic sea coast, viz., Artemisia canadensis, Glycyrrhiza lepidota, Corispermum hyssopifolium. Here Ptelea trifoliata, Juniperus communis, Lithospermum hirtum, are always lake shore plants. At Presque Isle, Pennsylvania on the shores of Lake Erie (See JENNINGS [4]), pages 309 and 328) grow Juncus balticus, Strophostyles helvola (= S. angulosa), Ammophila arenaria, Sieglingia purpurea, Cakile americana, Lathyrus maritimus, Euphorbia polygonifolia. The shore of the southwest extremity of Lake Michigan is characterized by a low sandy beach on which grow Lathyrus maritimus, Cakile americana, Euphorbia polygonifolia, Cenchrus tribuloides, Juncus balticus, Cnicus (Cirsium) Pitcheri [5]), Corispermum hyssopifolium, Prunus pumila, Populus monilifera.

*Sand Dune Formation.* The sand dunes of the Lacustrine Area are typically developed in northwest Indiana along the shores of Lake Michigan and we are indebted to COWLES for a description of the ecologic and floristic aspects of the same as well as for the Succession of the vegetation as influenced by the physiographic conditions [6]).

The dunes of this region are held in place by Ammophila arenaria, Elymus canadensis, Calamagrostis longifolia (the two latter of less importance) also Andropogon scoparius, A. furcatus, Chrysopogon natans, Eatonia obtusata. Certain shrubs occur: Salix adenophylla, S. glaucophylla, Prunus pumila, Cornus stolonifera, C. Baileyi, Populus monilifera with which dune formers are associated Artemisia canadensis, Cnicus Pitcheri, Lathyrus maritimus, Euphorbia polygonifolia,

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1) BECKWITH, FLORENCE, MACAULEY, MARY E. and FULLER, JOSEPH B.: Plants of Monroe County, New York. Proceedings Rochester Academy Science III, May 1906.

2) HOUSE, HOMER D.: Notes on the Flora of Oneida Lake and Vicinity. Torreya III: 165 Nov. 1903.

3) DAY, DAVID F.: The Plants of Buffalo and Vicinity. Bulletin of the Buffalo Society Natural History IV: 71.

4) JENNINGS, OTTO E.: A botanical Survey of Presque Isle, Erie County, Pennsylvania. Annals of the Carnegie Museum V: 289—417 with many fine plates XXII—LI; a paper printed, since this book went to press, and too detailed for a brief addition of its contents in the galley proof.

5) BEAL, W. J.: A Stroll along the Beach of Lake Michigan. American Naturalist IV: 356—358; BAILEY, L. H.: Michigan Lake shore Plants. The Botanical Gazette V: 90.

6) COWLES, HENRY C.: The ecological Relations of the Vegetation of the sand Dunes of Lake Michigan. Botanical Gazette XXVII: 95, 167, 281.

Corispermum hyssopifolium. The dune complex is characterized by Salix adenophylla, S. glaucophylla, Prunus virginiana, Populus monilifera, Vitis cordifolia, Andropogon scoparius, Arctostaphylos uva-ursi, Juniperus sabina var. procumbens, J. virginiana. The advancing dunes encroach upon a deciduous forest in the Lacustrine Area consisting of Tilia americana, Fraxinus americana. The established dunes are finally covered by trees and herbs of a typic mesophytic forest.

Certain dunes are covered by black oak Quercus tinctoria (= Q. velutina) associated with Quercus alba, Pinus Banksiana (= P. divaricata) and such shrubs as Sassafras officinale, Cornus florida, Amelanchier canadensis, Hamamelis virginiana, while on the lower or shaded slopes are Vaccinium vacillans, V. pennsylvanicum, Salix humilis, Viburnum acerifolium, Rosa blanda, R. humilis, Rhus copallina with a large number of herbs and Pteris (Pteridium) aquilina [1]).

*Swamp Formation.* Typic swamps are found in Oswego County, New York at the point where Lake Ontario makes the great bends to the north [2]). Such swamps began as a lake and were gradually filled by the encroachment of vegetation. In a swamp three typic horizons or circumareas of vegetation are recognizable: (1) the lagoon in the center; (2) the moor comprising the open area surrounding the lagoon and generally overgrowth with sphagnum; (3) the wooded circumarea comprising the outside of the swamp.

The vegetation of the lagoons consists of Potamogeton amplifolius. P. fluitans (= P. lonchites), P. heterophyllus, Naias flexilis, Potamogeton pauciflorus (= P. foliosus), Vallisneria *spiralis, Eleocharis mutata, Lemna triscula, L. minor, Spirodela polyrhiza, Heteranthera dubia (in* deep water). In the shallower water of such lagoons are Brasenia peltata (= B. purpurea), Nuphar adveua, Myriophyllum spicatum, Utricularia vulgaris, U. minor.

The flora of the moor circumarea consists of typic marsh plants such as Triglochin maritimum, T. palustris, Scheuchzeria palustris, Muhlenbergia glomerata (= M. racemosa), Glyceria canadensis, Calamagrostis canadensis, Carex filiformis, C. pauciflora, C. teretiuscula, C. magellanica, C. limosa, C. exilis, C. gynocrates (= C. Redowskyana), Peltandra virginica, Habenaria blephariglottis, H. tridentata (= H. clavellata), H. dilatata, H. leucophaea, Cypripedium spectabile (= C. reginae), Pogonia ophioglossoides, P. verticillata, Arethusa bulbosa, Listera australis, Calopogon pulchellus; Salix myrtilloides, S. candida are moor plants as also Sarracenia purpurea, Geum rivale, Sanguisorba canadensis, Ledum latifolium, Kalmia glauca, Andromeda polifolia, Lyonia (Chamaedaphne) calyculata, Chiogenes hispidula, Vaccinium Oxycoccus, V. macrocarpon, Menyanthes, Utricularia cornuta, U. intermedia, U. gibba, U. resupinata, Solidago ohionis, S. uliginosa, Aster junceus.

The wooded strip consists of trees which increase in number from the edge of the moor to the firmer soil on the edge of the swamp. The trees most frequently found are: Ulmus americana, Acer saccharum, Fraxinus sambucifolia, Pinus Strobus, Thuja occidentalis, Larix americana, Picea nigra (=P. mariana) and Betula lenta.

*Bog Formation.* The Mendon ponds of northwestern New York near Lake Ontario are associated physiographically with sphagnum bogs which represent former ponds captured by vegetation. Acres of bog are yellow with *Potentilla fruticosa.* Here occurs *Picea nigra*, while *Lyonia* (*Chamaedaphne*) *calyculata*, *Andromeda polifolia*, *Ledum latifolium*, *Vaccinium corymbosum*, *Gaylussacia resinosa*, *Nemopanthes fascicularis*, *Pirus* (*Aronia*) *arbutifolia* var. *melanocarpa*

1) Hill, E. J.: The sand Dunes of northern Indiana and their Flora. Garden and Forest IX: 353, 372, 382, 393.

2) Rowlee, W. W.: The Swamps of Oswego County, N. Y. and their Flora. American Naturalist XXXI: 690, 792, 1897.

and *Aralia hispida* are all present in great quantities. The herbs are much the same as quoted above for the "moor circumarea", and many orchids occur *Liparis Loeselii*, *Corallorhiza odontorhiza*, *Pogonia*, *Calopogon*, *Habenaria*, *Cypripedium spectabile*, *C. pubescens*, *C. parvifolium*, *C. acaule* are abundant, as also *Woodwardia virginica*, *Parnassia caroliniana*, *Decodon verticillatus*.

Bergen bog[1]) in its open part is covered with sedges, sphagnum and a few dwarf cedars Thuja occidentalis and tamaracks Larix americana (= L. laricina). The outer edge is a dense forest of cedars and tamaracks. The flora of this bog is very different from that of the surrounding country, and is characteristically northern[2]). Here are many rare plants: Lonicera coerulea (= L. villosa), Solidago neglecta var. linoides, S. Houghtoni, Senecio aureus var. balsamitae (= S. balsamitae), Microstylis monophylla, Corallorhiza innata, Goodyera repens, Arethusa bulbosa, Calypso borealis, Cypripedium candidum, Listera cordata, Clintonia borealis, Tofieldia glutinosa, Eleocharis rostellata, Scirpus caespitosus, Carex filiformis, C. Crawei, Dalibarda repens.

The tamarack bogs in Ohio are characterized by the presence of Larix americana, Sarracenia purpurea, Trientalis americana, Drosera rotundifolia, D. intermedia, Arethusa bulbosa, Coptis trifolia, Chiogenes hispidula, Cornus canadensis.

*Ravine or Gorge Formation.* The gorge of Niagara, where the spray of the cataract descends in an incessant shower, is a fitting habitat for a number of plants, among them *Hypericum Kalmianum*, *Parnassia caroliniana*, *Lobelia Kalmii*, *Campanula rotundifolia*, *Utricularia cornuta*, *Gentiana crinita*, *Carex Oederi*, etc. In other situations of similar character grow *Saxifraga aizoides*, *Primula mistassinica*, *Pinguicula vulgaris*, *Pterospora andromedea*[3]).

## 2. The Deciduous Forest Formation.

The Lacustrine Area was covered by an almost unbroken forest of deciduous trees which reached and covered the bluffs along the shores of the great lakes and extended in the form of more or less connected groves out into the prairies of Illinois. The primitive forest of the lake region of New York consisted of *Acer saccharum*, *Fagus*, *Fraxinus*, *Quercus alba*, *Q. bicolor*, *Q. rubra*, *Q. tinctoria* with *Q. macrocarpa*, *Q. Prinus*, *Q. coccinea* (infrequent), *Ulmus americana*, *U. fulva*, *Tilia*, *Castanea*, *Prunus americana*, *P. virginiana*, *P. serotina* (scarce), *Populus tremuloides*, *P. grandidentata*, *P. monilifera*, *Carya amara* (= *Hicoria minima*), *C. alba* (= *H. ovata*), *C. porcina* (= *H. glabra*), *Juglans cinerea*, *J. nigra*, *Platanus occidentalis*.

Less abundant and of secondary importance in the forest are Tsuga canadensis, Liriodendron tulipifera, Abies balsamea, species of Betula, Ostrya virginiana, Carpinus caroliniana, Hamamelis virginiana, Cornus florida. The rare trees in this forest are Celtis occidentalis, Nyssa sylvatica, Asimina triloba, Liriodendron tulipifera, Juniperus virginiana and Picea nigra. This forest on the

1) BECKWITH, FLORENCE, MACAULEY, MARY E. and FULLER JOSEPH B.: Plants of Monroe County, New York, Proceedings Rochester Academy Science III: May 1896.

2) It is a difficult matter to decide whether to place these bogs in the Interlacustrine Area of the Lake District, or not, but their geographic position has decided their place in this book.

3) DAY, DAVID F.: The Plants of Buffalo and Vicinity. Bulletin Buffalo Society Natural Sciences IV: 71.

lake bluff consists of Quercus alba, Castanea, Carya porcina, Populus monilifera, Tsuga, Hamamelis, and occasional trees of Pinus Strobus and rigida. The lianes are Vitis aestivalis, V. cordifolia, V. riparia, Ampelopsis quinquefolia.

In Ohio the forests on the ridge summits the steepest slopes and on the outcrops of Niagara limestone are of the white oak-, black oak-, hickory type. The most characteristic tree is *Quercus alba* associated with *Quercus rubra*, *Q. tinctoria*, *Q. obtusiloba*, *Q. imbricaria*, *Q. Prinus*, *Carya tomentosa* (= *Hicoria alba*), and the other named Hickories, while secondary in importance are *Cornus florida*, *Celtis occidentalis*, *Prunus pennsylvanica*, *P. serotina*, *Cercis*, *Sassafras*, *Acer saccharum*, *Juglans cinerea*, *J. nigra*.

Several stories are represented in the culmination of the deciduous forests about the southern shore of Lake Erie[1]. The composition of the first facies is more or less altered if the white pine Pinus Strobus associated with Juniperus virginiana, Ulmus fulva, Populus monilifera, Platanus occidentalis becomes at all prominent. The principal facies, however, consists of Quercus tinctoria and Q. imbricaria associated with Pinus Strobus, Tilia americana, Prunus virginiana, Ulmus americana, Prunus serotina, Fraxinus americana. Juniperus virginiana and such other plants as Smilax herbacea, Aralia nudiflora, Rubus villosus, Galium circaezans, Monarda fistulosa, Phryma leptostachya, Aralia racemosa, Ampelopsis quinquefolia, Lespedeza violacea, Solanum nigrum, Prenanthes (Nabalus) alba etc. These plants are arranged in layers with the tree facies uppermost and the shrubs and herbs beneath. Where the accumulation of humus in the soil is greater, the facies consists of Ulmus americana and Acer rubrum with such secondary species as Fraxinus americana, Quercus tinctoria, Platanus occidentalis, Acer nigrum, Ostrya.

In the drainage valleys and level country occurs a strictly mesophytic forest consisting of the following component species: Ulmus americana, Acer dasycarpum (= A. saccharinum), Fagus, Tilia, Quercus macrocarpa, Ulmus fulva, Quercus bicolor, Q. palustris, Carya amara (= Hicoria minima), Fraxinus quadrangulata, Fraxinus viridis. The shrubs are Lindera (Benzoin) benzoin, Xanthoxylum americanum. The usual spring plants occur in these woods and in autumn Eupatorium ageratoides, Impatiens fulva, Aster novae-angliae, Lobelia syphilitica, Sanicula marylandica, Aralia racemosa.

Certain sand dunes in Wyandot County, Ohio[2] are covered with Ulmus, Quercus alba, Acer sacharinum (= A. dasycarpum), A. rubrum, Populus monilifera, Prunus serotina, Quercus imbricaria, Fraxinus americana, while on the low ground adjoining grow Ulmus americana, Quercus palustris, Q. bicolor, Acer rubrum. A perfect tangle of shrubs is met with consisting of Cornus stolonifera, Rhus glabra, Corylus americanus, Rubus villosus, Euonymus atropurpureus, Smilax herbacea, S. hispida, Celastrus scandens, Staphylea trifolia, Sambucus canadensis, Pirus (Malus) coronaria, Populus tremuloides, Cornus florida.

Indiana was once almost entirely covered with noble forests of deciduous trees. Along its western borders these were interrupted, however, by numerous small prairies. The forests of this state are characterized by an almost entire absence of coniferous trees. In the original condition the uplands of northern Indiana were covered with a forest of various species of oaks, hickories, *Juglans nigra*, *Liriodendron*, *Prunus serotina*, *Fraxinus americana*, *Ulmus americana*. The undergrowth consisted of *Xanthoxylum americanum*,

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1) JENNINGS loc. cit. describes in a detailed manner the succession on Presque Isle terminating in a forest where Quercus tinctoria (= Q. velutina) is the dominant tree.

2) BONSER, THOMAS, A.: Ecological Study of Big Spring Prairie, Wyandot County, Ohio. Ohio State Academy of Science. Special Papers No. 7. 1901.

*Rubus villosus*, *R. occidentalis*, *Gaylussacia resinosa*, *Ptelea trifoliata*, *Hamamelis virginiana*, while the forest floor is covered with a carpet of *Cystopteris*, *Adiantum pedatum*, *Arisaema*, *Podophyllum*, *Hieracium*, *Helianthus divaricatus*, *Hepatica*, *Impatiens*, *Anemonella thalictroides*, *Galium*, *Seymeria*, *Gerardia*. There is an abundance of fungi growing upon the leaf-mold, viz: Myxomycetes, Boleti and various Agaricineae.

Near the summit of sand-gravel-clay hills are the following trees: *Quercus tinctoria*, *Q. alba*, *Carya alba* (= *Hicoria ovata*), *C. sulcata* (= *H. laciniosa*), with *Ceanothus americanus*. The beech-maple forest exists in deep rich soils. Accompanying the beech and the sugar maple are *Liriodendron*, *Juglans nigra*, *Asimina triloba*, while beneath on the ground are *Hepatica triloba*, *Podophyllum peltatum*, *Symplocarpus foetidus*, etc. [1]).

This deciduous forest extends into southern Michigan where trees like *Liriodendron*, *Asimina*, *Cercis*, *Gleditschia*, *Cornus florida*, *Nyssa sylvatica* and *Morus rubra* have crept northward favored by the mild influence of the lake winds and the same is true of the associated herbaceous species. The main hardwood forest lies south of the parallel of 43° north latitude. On the uplands the prevailing forest is a beech-maple and oak association.

## b) Kentucky-Tennessee Area.

This area phytogeographically considered includes the territory comprehended by the southern parts of Ohio [2]), Indiana, Illinois along the Ohio River and including the drainage basin of that river, the western part of West Virginia, also along the Ohio River, the states of Kentucky and Tennessee and northwestern Alabama. In fact, this area may be said to cover the drainage basin of the Ohio River and its tributaries the Tennessee, the Cumberland, the Green, the Kentucky, the New, the Scioto and the Wabash rivers. In this area, the deciduous, or hardwood forests reign supreme and the associations of plants are in general of a mesophytic character.

### 1. Deciduous Forest Formations.

West Virginia has a larger amount of hardwood timber in its forests than any other state. These splendid forests cover over sixteen thousand square miles and yield the following species:

| | |
|---|---|
| Pinus Strobus L. | Juniperus virginiana L. |
| » mitis Michx. (= P. echinata Mill.). | Salix nigra Marsh. |
| » rigida Mill. | Populus monilifera Ait. (= P. deltoides Marsh.). |
| Tsuga canadensis L. | |

1) CLARK, H. WALTON: Flora of Eagle Lake and Vicinity. Proceedings Indiana Academy Science 1901, 200—202.

2) GREEN, W. J. and SECREST, EDMUND: Forest Conditions in Ohio. Bulletin of the Ohio, Agricultural Experiment Station No. 204, June 1909; also PLOWMANN, A. B.: Forestry and Irrigation XIV: 363—369. July 1908.

Juglans cinerea L.
» nigra L.
Carya amara Nutt. (= Hicoria minima Marsh.).
» porcina Nutt. (= Hicoria glabra Mill.).
» alba Nutt. (= Hicoria ovata Mill.).
Ostrya virginiana Mill.
Carpinus caroliniana Walt.
Betula lenta L.
Fagus americana Sweet (= F. ferruginea Ait. = F. grandifolia Ehrh.).
Castanea dentata Marsh. (= C. americana Michx.).
Quercus tinctoria Bartr. (= Q. velutina Lam.).
» falcata Michx. (= Q. digitata Marsh.).
» palustris Muench.
» imbricaria Michx.
» Prinus L.
» aquatica Walt. (= Q. nigra L.).
» alba L.
» rubra L.
Ulmus americana L.
» fulva Michx. (= U. pubescens Walt.).
Celtis occidentalis L.
Maclura aurantiaca Nutt. (= Toxylon pomiferum Raf.).
Morus rubra L.
Magnolia acuminata L.
» umbrella Lam. (= M. tripetala L.).
Liriodendron tulipifera L.
Asimina triloba Dunal.
Sassafras officinale Nees & Ebrem.
Hamamelis virginiana L.
Liquidambar styraciflua L.
Platanus occidentalis L.
Prunus serotina Ehrh.
Pirus (Malus) coronaria L.
Amelanchier canadensis L.
Crataegus coccinea L.
Robinia pseudacacia L.
Gleditschia triacanthos L.
Cercis canadensis L.
Zanthoxylum americanum Mill.
Aesculus glabra Willd.
Negundo aceroides Moench (= Acer negundo L.).
Acer saccharinum L. (= A. dasycarpum Ehrh.).
Acer rubrum L.
Rhus typhina L. (= R. hirta L.).
Ilex opaca Ait.
Vitis labrusca L.
Tilia americana L.
» heterophylla Vent.
Aralia spinosa L.
Cornus (Cynoxylon) florida L.
Nyssa sylvatica Marsh. (= N. multiflora Wang.).
Diospyros virginiana L.
Halesia tetraptera L. (= Mohrodendron carolinum L.).
Fraxinus americana L.
» nigra Marsh. (= F. sambucifolia Lam.).
Viburnum prunifolium L.
Lindera (Benzoin) benzoin L.[1]).

As an illustration of the composition of the West Virginian forest situated between the lower portions of the great Kanawha (New River), the Big Sandy near where these rivers empty into the Ohio may be mentioned the following enumeration of trees on a tract of land 655 acres in extent on the top of a dividing ridge between two streams. It was found that 16,989 trees, or an average of twenty-six large timber-trees to the acre were growing on the 655 acres. Of these 1986 were Quercus alba, 5886 were Q. Prinus, 1100 were Q. tinctoria, 736 were Q. rubra, 2547 were hickories (species not given), 1900 were Castanea dentata,

1) C. MILLSPAUGH, C. F. Flora of West Virginia. Publ. Field Columbian Museum Botanical Series I, No. 2; 77—80.

207 were Robinia pseudacacia, 330 were maples (species not given), 333 birches, 858 Liriodendron tulipifera, 939 were pines and 167 were Tilia americana. The percentage of hardwoods is therefore about 88 percent. The record[1]) shows that most of the trees were of large size, the oaks for example ranging in diameter from eighteen to sixty inches (46—152 cm).

The early settlers in southern Indiana found the country one vast forest broken only by the wind swept streak of the cyclones or the marshy land of the prairies. *Juglans nigra* was abundant in this forest and on the hills back of the Ohio River, *Fagus americana* was abundant forming an almost exclusive growth. Elsewhere the forest was of the mixed type and an enumeration in 1876 showed the following percentage[2]):

| | | | |
|---|---|---|---|
| Fagus americana Sweet | 35 per cent | Juglans nigra L. | 5 per cent |
| Quercus (several species) | 18 » » | Carya alba Nutt. (= Hicoria ovata Mill.) | 5 » » |
| Liriodendron tulipifera L. | 10 » » | Platanus occidentalis L. | 3 » » |
| Acer rubrum L. / Acer saccharum Marsh | 5 » » | Aesculus glabra Willd. / Aesculus flava Ait. | 2 » » |
| Fraxinus americana L. / Fraxinus quadrangulata Michx. | 5 » » | Ulmus americana L. | 2 » » |
| | | Other species | 10 » » |
| | | | 100 |

To appreciate something of the size of the trees of this forest, we need but note the following (measurements in feet):

| | Diameter | Height to First Limb | Total: Height |
|---|---|---|---|
| Quercus macrocarpa Michx. | 7 | 72 | 160 |
| Quercus alba L. | 6 | 60 | 150 |
| Quercus tinctoria Bartr. (= Q. velutina Lam.) | 6.5 | 75 | 165 |
| Quercus rubra L. | 7 | 94 | 181 |
| Juglans nigra L. | 7 | 74 | 155 |
| Populus monilifera Ait. (= P. deltoides Marsh.) | 8 | 91 | 190 |
| Acer saccharum Marsh. | 5 | 62 | 120 |

Perhaps of the same floristic constitution is the most remarkable aggregation of trees in the north temperate zone found in the lower Wabash Valley in Illinois where the number of indigenous species south of the mouth of White River is one hundred and seven. This forest may be considered to represent the most northern extension of hardwood bottom forests of the Arkansas-Louisiana District where they have already been described[3]).

The dry bottom-land on the Illinois side of the Mississippi River[4]) opposite St. Louis is characterized by a sandy soil which supports a rich and diversified vegetation. The principal trees in places that are wooded comprise *Quercus tinctoria*, *Q. imbricaria*, *Q. macrocarpa*, *Q. Muhlenbergii* (= *Q. acuminata*), *Acer saccharinum* (= *A. dasycarpum*) and *Ulmus fulva*. The wet

1) Hotchkiss, Jed.: Garden and Forest, V.; 155. March 30, 1892.

2) Coulter, M. S., Botanical Gazette I; 15.

3) See ante Arkansas-Louisiana District (Ch. 2. D. page 455) Hardwood Bottom Formation.

4) Hus, Henri: An ecological Cross Section of the Mississippi River in the Region of St. Louis, Mo. 19th Annual Report Missouri Botanical Garden 1908: 127—258.

bottom shows clumps of willows consisting of *Salix amygdaloides*, *S. cordata*, *S. longifolia* and *S. nigra*. Species of *Crataegus* occur as isolated individuals which in some cases are the only representatives of the species, the Mississippi acting as a barrier to their general distribution westward, as is the case also with *Gleditschia aquatica* which occurs on the Illinois side, but not in Missouri.

The wooded bottom is characterized by Carya amara (= Hicoria minima), C. olivaeformis (= H. pecan), Quercus bicolor, Q. macrocarpa, Q. palustris, Gleditschia triacanthos, Populus monilifera, Celtis mississippiensis, C. occidentalis, Betula nigra, Ulmus americana, and such lianes as Ampelopsis quinquefolia, Vitis cinerea, V. cordifolia, V. riparia. The herbaceous flora of the dry bottoms includes Myosurus minimus, Ranunculus abortivus, R. repens, Anemone pennsylvanica, Dentaria laciniata, Draba brachycarpa, D. caroliniana, Sisymbrium canescens, Cerastium nutans and Geranium carolinianum (in rosettes). The summer adds Cassia chamaecrista, Crotalaria sagittalis, Desmodium canescens, D. bracteosa (= D. cuspidatum), D. Dillenii, D. paniculatum, Glycyrrhiza lepidota, Lespedeza capitata, L. violacea, Ambrosia artemisiaefolia, A. bidentata, Aster patens, Helianthus annuus, H. tuberosus, Solidago canadensis, S. serotina and others.

On the wet bottoms are found Isopyrum biternatum, Myosurus minimus, Ranunculus abortivus, succeeded in summer by Hypericum mutilum, H. perforatum, Cassia chamaecrista, Abutilon Avicennae, Amorpha fruticosa, Baptisia leucantha, Asclepias incarnata, Ipomoea hederacea, I. lacunosa, I. pandurata, I. purpurea, Convolvulus sepium, Stachys palustris, Datura stramonium, D. Tatula, Phytolacca decandra, Polygonum acre, P. hydropiperoides, P. lapathifolium, Euphorbia glyptosperma, E. humistrata and Boehmeria cylindrica.

Upland Deciduous Forest Formation. The woods which extend back from the river bluffs toward the prairies are decidedly different from those of the alluvial bottoms. The trees are of lighter growth and the species are fewer in number. The predominating trees are several species of *Quercus* and *Carya* which vary according to locality. The undergrowth lacks rankness, consisting of patches of hazel, *Corylus americana*, thickets of *Prunus americana*, *Pirus coronaria*, beneath which are *Frasera carolinensis*, *Arisaema triphyllum*, *Podophyllum peltatum* and other herbs. The vines of these woods are *Tecoma radicans*, *Bignonia capreolata (= B. crucigera)*, several species of *Smilax*, *Humulus lupulus*, *Dioscorea villosa*, *Rosa setigera*. The Oak Openings are a striking feature of southern Illinois and they afford a transition to the prairie formation to be considered later in this work. The characteristic oaks *Quercus imbricaria*, *Q. aquatica (= Q. nigra)*, or in damp situations *Q. palustris* are of symmetric shape, uniform size and compact foliage. They arise from a grassy turf seldom encumbered with brush but not infrequently broken by dense growths of dwarf sumac and flowering plants.

The plateau region of Tennessee is covered by a forest of broad-leaf trees which grow on the rolling surface with a soil of poor quality, loose and sandy. The following trees distributed originally according to their soil and moisture preference occur:

Carya porcina Nutt. (= Hicoria glabra [Mill.]).
Salix nigra Marsh.
Castanea dentata Marsh.

Quercus obtusiloba Michx. (= Q. stellata Wang.).
Muhlenbergii Engelm. (= Q.

Quercus coccinea Muench.
» tinctoria Bartr. (= Q. velutina Lam.).
» aquatica Walt. (= Q. nigra L.).
Sassafras officinale Nees & Eberm. (= S. variifolium Salisb.).
Liriodendron tulipifera L.
Liquidambar styraciflua L.
Platanus occidentalis L.
Amelanchier canadensis L.
Robinia pseudacacia L.
Rhus venenata DC. (= R. vernix L.).
Acer rubrum L.
Cornus (Cynoxylon) florida L.
Oxydendrum arboreum L.
Kalmia latifolia L.
Diospyros virginiana L.

*Quercus alba* follows the deep loamy soil of the hollows; *Liriodendron* grows a little higher up, where it mingles on the slopes with *Quercus coccinea*, *Castanea dentata*, grows on the thin dry soil of the ridges, while *Acer rubrum* confined itself to the swampy hollows. *Oxydendrum arboreum* grows on the creek slopes, while *Salix nigra* clings to the water's edge with *Robinia pseudacacia*, *Diospyros virginiana*, *Cornus florida* on the levels [1]).

On the summits of the sharper ridges of the plateau the forest is composed of Castanea dentata, Q. Prinus and Q. coccinea. The chestnuts predominate in this type of forest. A little below the ridges on the slopes grows as the dominant tree, Quercus coccinea, associated with Quercus alba, Carya porcina (= Hicoria glabra), Nyssa sylvatica (= N. multiflora), Quercus Prinus, Q. obstusiloba (= Q. minor), Liriodendron tulipifera (a few trees). The broad level tops of some of the ridges and certain bottom lands are classed as oak flats with a relatively good soil. Here white oaks Quercus alba are found and Q. coccinea, Q. obtusiloba and Carya porcina (= Hicoria glabra). The soil of the low land which lies at the foot of the slopes is always the deepest and most moist on the plateau. The swampy bottoms contain Acer rubrum, Nyssa sylvatica, Liquidambar styraciflua with Quercus alba and Liriodendron tulipifera on the drier ground.

## 2. Barrens, Cliffs and Cedar Glades.

*Barren Formation.* The barrens of southern Indiana occupy a large area in the corners of four counties, Clarke, Floyd, Washington and Harrison. Sink holes abound in a country covered with flinty stones and concretionary boulders. As a result thickets of scrub oak and small shrubby plants abound with openings of some extent between which were found *Liatris scariosa*, *Eupatorium sessilifolium L.* [2]), *Brachychaeta cordata*, *Solidago rigida*, *S. nemoralis*, *Silphium trifoliatum*, *Rudbeckia laciniata*, *Lepachys pinnata*, *Helianthus mollis*, *H. rigidus*, *H. parviflorus*, *H. hirsutus*, *Dysodia chrysanthemoides*, *Stylosanthes elatior*, *Desmodium rotundifolium*, *Lespedeza procumbens*, *Tephrosia virginiana*, *Strophostyles helvola*, *Eryngium yuccaefolium.* Similar barrens are also found in southern Illinois.

*Cedar Barren Formation.* In the highlands of middle Tennessee the somber tint of the red cedar *Juniperus virginiana* delineates a cedar barren where the rock is exposed and where occur beneath the trees, (viz: *Celtis*, *Gleditschia*,

1) FOLEY, JOHN: Conservative Lumbering at Sewanee, Tennessee. U. S. Bureau of Forestry Bulletin 39 (1903); 8—9.

2) COULTER, J. M.: The Barrens of southern Indiana. Botanical Gazette II: 145.

*Ulmus*, *Quercus obtusiloba* and *Q. imbricaria)* a host of herbaceous plants, such as *Sedum pulchellum*, *Arenaria patula*, *Scutellaria nervosa*, *Talinum teretifolium*, *Astragalus plattensis*, *A. caryocarpus*, *Psoralea subacaulis*, *Baptisia australis*, *Houstonia patens*, *Anemone caroliniana*, *Viola pedata* var. *bicolor*, *Heliotropium tenellum*, *Phlox stellaria.* The shrubs of these rock outcrops are *Ptelea trifoliata*, *Rhus canadensis (= R. aromatica)*, *Forestiera ligustrina*, *Callicarpa americana.*

The forests of Kentucky resemble in general features those of Tennessee. The central region is covered by a hardwood forest while in the western part the river swamps are occupied by *Taxodium distichum* and associated species. This part of the state, therefore, must be excluded from our description at this point because it has been described previously. One or two special features of the Kentucky flora now claim our attention.

*Cliff Formation.* The cliffs along the Kentucky and Dix rivers consist of limestone [1]). Growing in the crevices of these cliffs, as chasmophytes, are found *Silene rotundifolia*, *Polygala senega*, *Galium trifidum*, *G. circaezans*, *Nemophila microcalyx*, *Enslenia albida*, *Tradescantia pilosa*, *Arenaria patula* and such trees as *Juniperus virginiana*, *Ulmus racemosa* and *Cladrastis tinctoria (= Virgilia lutea).*

The Illinois cliff flora proper presents a rosette physiognomy not differing materially from that described in the Ozark Area on the Missouri side of the Father of Waters. The talus at the foot of the Illinois bluffs presents the same general aspect as on the Missouri side, according to HUS [2]), although the exposure is diametrically opposite.

The talus slope (shingle) vegetation is richer on the Illinois side and comprises Stylophorum diphyllum, Arabis brachycarpa (= A. confinis), Viola striata, Hypericum Ascyron, Epilobium coloratum, Osmorrhiza longistylis, Bidens connata, Vernonia altissima, Phacelia bipinnatifida, P. Purshii, Euphorbia obtusata, Habenaria virescens (= H. flava), not found on the Missouri side. Large springs issue from the face of the Illinois bluff permiting the growth of numerous liverworts and algae. The occurrence of the lithophyte, Chlorotylium mammillosum which covers the rocks at Falling Spring with a green felt is to be noted here.

*Cave Associations.* Southern Kentucky is a cavernous country where sinks or sink holes abound. *Actaea alba* occur only in sink holes with *Impatiens pallida*, *Scrophularia nodosa*, *Collinsonia canadensis*, *Asplenium angustifolium. Cystopteris fragilis* is common in the crevices of moist limestone rock, while *Asplenium ebeneum* is on the rocks nearer the surface. *Pellaea atropurpurea* grows at cave entrances, and *Nephrodium (Polystichum) acrostichoides* grows in the woods near the top of the sink. Mats of walking fern *Camptosorus rhizophyllus* are also occasionally found in the bottom of sinks. About the entrance

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1) EVANS, HARRY A.: The relation of the Flora to the geological Formations in Lincoln County, Kentucky. Botanical Gazette XIV: 310—314.

2) Ecological Cross Section of the Mississippi River. 19th. Rep. Miss. Bot. Garden 1908, 127—258.

of caves in the sandstone region grow *Nephrodium spinulosum* var. *intermedium*, and *marginale*, *Cheilanthes vestita* and *Asplenium pinnatifidum*[1]).

This deciduous-leaved forest has its southern extension in the Tennessee valley in northern Alabama where decidedly northern types prevail with many plants found in the Ohio valley not seen in other parts of Alabama, such as: *Aesculus flava*, *A. glabra*, *Acer saccharum*, *Cladrastis tinctoria*, *Staphylea trifolia*. Pines are almost totally absent in this valley.

North of the Tennessee River the detached spurs of the Cumberland Mountains rise to an elevation of 1200 to 1500 feet above sea level. The flat tablelands are covered with a mesophytic type of forest which begins at the headwaters of the Ohio River in Pennsylvania and stretches southward west of the mountains to this point where it reaches its southern limit. Species of oaks form the predominating forest growth of these highlands, viz: *Quercus alba*, *Q. Prinus*, *Q. tinctoria*, *Acer saccharum* var. *barbatum* associated with *Magnolia acuminata*, *Tilia heterophylla*, *Aesculus flava*. The valleys on the other hand skirting the detached spurs of the mountains are filled with a forest of *Liriodendron tulipifera*, *Quercus alba*, *Tilia*, *Fraxinus*, *Sassafras*, *Juglans nigra* and *Juniperus virginiana* of superior quality occupying the damp rocky recesses[2]). *Rhus (Cotinus) cotinoides* makes its appearance on the calcareous summits and upon the shelves where the sandstones overlie the calcareous rocks on the flanks of the higher mountains.

Barrens also occur in the northern part of the Tennessee Valley covered with an open forest of upland oaks and trees of stunted growth. Such grasses as *Andropogon virginicus*, *Agrostis hiemalis*, *Panicum commutatum*, *Eleocharis tenuis*, *Cyperus ovularis* are found associated with *Phlox maculata*, *Steironema lanceolatum*, *S. ciliatum*, *Coreopsis senifolia*, *Ceanothus americanus*, *Polygala incarnata* and *Lespedeza striata*.

South of the Tennessee River, lowlands border the principal streams and these are covered with extensive hardwood forests of *Quercus Michauxii*, *Q. texana*, *Q. phellos*, *Q. falcata* associated with *Carya tomentosa* (= *Hicoria alba*), *Fagus*, *Fraxinus*, *Carpinus*, *Asimina*, *Ilex decidua*, *Crataegus apiifolia*, *C. crus-galli* and *C. spathulata*. The benches of mountain limestone are covered with oaks. The herbaceous flora of the forests of the bottom and bench land comprises but a small number of shade loving species, viz: *Chimaphila maculata*, *Galium circaezans*, *Mitchella repens*.

*Cedar Glade Formation*. The lower terraces of the higher ridges are almost bare of soil. On these rugged grounds the red cedar *Juniperus virginiaua* abounds with stunted forms of *Fraxinus quadrangulata* and a form of white ash *Fraxinus americana*. On the sunny exposures in the openings and borders of the forest which covers the calcareous hills where the soil is deeper are found: *Rhamnus caroliniana*, *Viburnum prunifolium*, *Bumelia lycioides*,

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1) PRICE, SADIE F.: Cave Plants. Garden and Forest VI. (1893): 403.

2) MOHR, CHARLES: Plant Life of Alabama. Contributions U. S. National Herbarium, VI: 84.

*B. lanuginosa*, *Crataegus coccinea*, *Cornus asperifolia*, *Ostrya virginiana*. *Rhu (Cotinus) cotinoides* is confined in Alabama, to the mountain limestone.

The herbaceous associations are naturally xerophile. On the exposed rocks small cruciferou plants, as chasmophytes, fill every crevice, viz: Leavenworthia aurea, L. uniflora, L. tomentosa Draba caroliniana, D. brachycarpa the first harbingers of springtime. In late spring slightl sheltered rocks are adorned with flowers of Oxybaphus (Allionia) nyctaginea, Ranunculus fasci cularis, Arabis laevigata, Claytonia virginica, Arenaria serpyllifolia, Opuntia Rafinesquii, Geraniur maculatum, Lithospermum canescens, L. tuberosum, Salvia urticaefolia, Scutellaria campestris Bellis integrifolia. Sedum pulchellum, Phacelia Purshii grow in the interstices of rocky fragment and Arenaria patula occurs on bare rocks. The spring plants are succeeded by Hypericum aureum H. sphaerocarpum, Aster oblongifolius, A. cordifolius, Solidago amplexicaulis and Brachychaet cordata (= B. sphacelata).

The isolated knolls of silicious limestone rising above the wide river plain support in thei scanty soil a stunted growth of Quercus Muhlenbergii (= Q. acuminata), Prunus americana Gleditschia triacanthos, Ostrya virginiana and under their shade Liparis liliifolia, Cypripediun parviflorum, Delphinium tricorne, Dentaria laciniata, Mertensia virginica.

## c) Ozark Area.

As an area of varied territories it includes, as shown on the map, portion of Missouri, north-western Arkansas, Indian Territory reaching its southern limi in eastern Texas. The past few years have seen an active investigation o the flora from a phytogeographic standpoint.

Southern and southwestern Missouri were originally covered with a dens forest of hardwood, in which were extensive areas of short-leaved pines *Pinu mitis (= P. echinata)* covering gravelly ridges and the lower Ozark hills The region south and southwest of the Archaean outcrops in the southeaster part of the state on the silicious soils was dominated by this pine. The north western corner of the state is partly prairie formation and there the trees ar confined mostly to the broad bottom lands in belts often two or thre miles in width. Southeastern Missouri belongs to the Arkansas-Louisian phytogeographic district where forests of Mississippi valley type abound The flora in the Ozark Plateau may in general be said to have som distinctly Appalachian elements, but with many peculiarities common to th extension of this ridge into Arkansas, Tennessee and Alabama.

The Ozark Mountain region was first supplied with trees from Kentucky and other southern Appalachian districts. When trees were once established in the Ozark this region served as a base of supply from which the territory to the north, west and southwest was stocked. The Minnesota forest had much less influence on the prairies [1]). Barrens of post oak *Quercus obtusiloba (= Q. minor)* are a feature of the Ozark country. There are many species of trees and plants common to this region, but there are others such a *Fagus americana*, *Carya olivaeformis* and *C. alba* (= *Hicoria pecan* and *ovata*)

1) DUGGAR, B. M., Plant Life in Missouri; in Williams' The State of Missouri 1904: 229—240

*Tilia americana* and *Liquidambar styraciflua*, *Celastrus scandens*, *Dirca palustris* are sparingly distributed[1]).

Aquatic plants are scarce but there are species of Lemna (L. minor, L. Valdiviana), Spirodela (S. polyrhiza), Potamogeton (P. Hillii, P. pusillus), Ceratophyllum (C. demersum), Nelumbo (N. luteum), Philotria, Alisma (A. Plantago), Sagittaria (S. variabilis, S. platyphylla), Typha, Sparganium, Zizania in such pools as do occur.

In slow-flowing streams with leaves floating in the direction of the current are found Potamogeton fluitans, P. hybridus, while the submerged aquatics are two other species of Potamogeton with Naias flexilis, Elodea minor, Ceratophyllum demersum. The muddy shores and low alluvial flats accommodate plants which stand in shallow water, such as, Eleocharis acuminata, E. tenuis, E. intermedia, E. palustris, E. Engelmanni, E. ovata, Cyperus flavescens, C. diandrus, C. acuminatus, Carex Frankii, Eragrostis hypnoides, Juncus nodosus, J. acuminatus, J. scirpoideus, Heteranthera, Ranunculus septentrionalis, R. abortivus, Ludwigia, Nasturtium, Cardamine pennsylvanica, Conobea, Ilysanthes, Eclipta.

Sinkhole Pond Formation. Here and there on the Missouri Plateau according to Hus[2]) see 505 footnote 4) the deciduous forest formation is interrupted by small ponds formed by the obstruction of the underground drainage of the limestone sinks. The hydrophytic flora of such ponds consists of Heteranthera limosa, Pontederia cordata, Sagittaria variabilis (in the shallower pools), Jussiaea repens, Lemna perpusilla, Wolffia punctata while large quantities of Riccia natans also occur. The surrounding vegetation consists of grasses and sedges.

## 1. Deciduous Forest Formations.

The forests of Missouri may be divided into two types, viz: the upland and lowland forests.

*Upland Forest Formation.* The upland forest includes, as most common representatives in the northern and central portions of the state, a considerable variety of oaks, hickories, the black walnut. This forest type in southern Missouri is much richer in species than the forests situated back from the streams in the northern portion of the state. The disposition of the trees is governed by soil and exposure — *Quercus alba* is found on the ridges in the southeast and gives stamp to nearly all the wooded uplands throughout the middle and northern portion of the state. Occupying a considerable territory west of the region of pine and white oak, there is found the black jack-scrub oak associations. The deciduous forest in the vicinity of Columbia, Missouri, according to DANIELS[3]) consists typically of the Oak Facies. Here occur *Quercus alba* adapted to a wide range of soils associated with the bur oak *Quercus macrocarpa* on the heavier soils in swamps and along streams, *Q. platanoides*, *Q. palustris*, *Q. rubra*, *Q. texana* (= *Q. Schneckii*), *Q. acuminata*, *Q. tinctoria*, *Ulmus*, *Juglans nigra*, *Carya alba*, *C. sulcata*, *C. tomentosa*, *C. porcina*, *C. amara* (*Hicoria ovata*, *H. laciniosa*, *H. alba*, *H. glabra*, *H. minima*), *Celtis*, *Gleditschia*, *Gymnocladus*, *Acer saccharum* and *nigrum*, *Aesculus glabra*, *Diospyros*, *Fraxinus*.

1) LA MANCE, LORA S.: Rambling Notes from the Ozarks. Garden and Forest V: 525.

2) This paper of 130 pages with valuable phytogeographic and phenologic data was received too late to incorporate all of its important results in this volume of "Die Vegetation der Erde". It should be consulted by all students of the flora of the Mississippi Valley.

3) The Flora of Columbia Missouri and Vicinity. University of Missouri Studies I No. 2.

'he herbaceous plants that occur in these forests are found in several seasonal aspects. vernal herbs are Carex pennsylvanica, Trillium sessile, Claytonia virginica, Podophyllum um, Dentaria laciniata, Oxalis violacea, Viola pubescens, Polemonium reptans, Pedicularis ensis. The estival herbs of the forest floor in Missouri are of the ferns Adiantum pedatum, pteris fragilis, Nephrodium (Polystichum) acrostichoides, Botrychium virginianum, Muhlen- sylvatica, M. diffusa, Agrostis perennans, Carex retroflexa, Cassia marylandica, Geranium tum, Aralia racemosa, Thaspium aureum, Cynoglossum virginicum, Monarda fistulosa, Pent- hirsutus, Triosteum perfoliatum, etc. The serotinal herbs are Desmodium nudiflorum, iescens, D. Dillenii, Gerardia grandiflora, Solidago ulmifolia, S. serotina, S. canadensis, ithus hirsutus, Hieracium scabrum.

'he bottom of the ravines occupied by a stream that runs dry in ner is characterized by a modification of the forest described above known e Blue Beech Facies. *Here occur in association Juglans cinerea, Carya a (= Hicoria minima), Carpinus caroliniana, Ostrya virginiana, Quercus macrocarpa, acuminata, rubra, Morus rubra, Asimina, Platanus occiden- Cercis, Rhus toxicodendron, Euonymus atropurpureus, Celastrus scandens, dasycarpum, Vitis riparia, Ampelopsis.*

he prevernal ravine plants possess bulbs, bulb-like corms, rootstocks, or tubers. re Sanguinaria canadensis, Claytonia virginica, Erythronium albidum, Isopyrum biternatum, ra cucullaria, Dentaria laciniata, Erigenia bulbosa, Phlox divaricata, Collinsia verna. The l ravine herbs consist of plants that mature their fruits in late summer and autumn, sing Uvularia grandiflora, Smilacina racemosa, Polygonatum biflorum, Cypripedium parvi- (very rare), Thalictrum purpurascens. The aestival flora is not well-marked and the ludes Agrimonia striata, Zizia aurea, Sanicula canadensis. The autumnal woodland ravine ; are Campanula americana, Lobelia syphilitica, Eupatorium ageratoides and Solidago flexi-

he Walnut Facies of rich slopes consists of Juglans nigra, various hickories, Quercus Q. acuminata in control, but often the ironwood, Ostrya virginiana covers the lower with Rhus glabra and Corylus americana. The herbs in general are those common to the — The Blue Ash (Fraxinus quadrangulata) Facies of hills summits consists of this gether with Quercus tinctoria (= Q. velutina), Q. alba, Q. imbricaria, and Diospyros virgi- Shrubs and undershrubs are frequent. The herbs are semi-xerophytic such as Astragalus nus, Antennaria plantaginifolia, Comandra umbellata. — The Elm Facies occupies the of the coal measures north of Columbia, Missouri. The dominant trees are Ulmus cana, Quercus macrocarpa, Q. platanoides, Q. palustris, Q. rubra. The white oak is ly scarce. The black cherry Prunus serotina is frequent and the red cedar Juniperus virgi- s common on hill slopes. — The Sassafras Facies occupies light soils. Here are is Sassafras, Quercus tinctoria (= Q. velutina), Q. imbricaria, Q. rubra, Q. texana (= Q. kii) with herbs that prefer light dry soils.

*wland Deciduous Forest Formation.* The lowland forests of the river s and alluvial plains afford a heavy growth of timber consisting of poplars *lus*), Sycamore (*Platanus occidentalis*), willows (*Salix*) and others.

: the point where the Missouri River enters Kansas in Jackson County, uri, the forest of the bottom lands consists of giant elms ***Ulmus ameri- U. fulva, Platanus, Populus monilifera (= P. deltoides), Quercus macro- , Juglans nigra, Gymnocladus canadensis (= G. dioica), Salix nigra, lus arguta, Acer dasycarpum*** with such small trees as ***Ostrya virginiana,***

*Pirus Ioënsis*, species of *Crataegus* and *Prunus* with such undershrubs as *Symphoricarpos occidentalis* and *Corylus americana*.

In the open parts of these forests[1] are Tricuspis (Sieglingia) sesleroides, Helianthus tuberosus var. subcanescens, Anemone pennsylvanica (= A. canadensis), Apocynum hypericifolium, Vernonia maxima, Solidago serotina, Aster missouriensis, Aster paniculatus and various species of Bidens. In the denser forest, various lianes are found Cissus ampelopsis (= Ampelopsis cordata), Vitis vulpina, Clematis Pitcheri, Rhus radicans, with such rare orchids that grow in the shade, viz: Aplectrum hiemale (= A. spicatum), Spiranthes plantaginea, Pogonia pendula (= P. trianthophora) and the saprophytic plant, Monotropa uniflora.

The alluvial forest in Missouri, according to DANIELS, shows several well characterized faces. The Basswood (Tilia americana) Facies occurs on the flats of the streams. There enter into the composition of the facies: *Juglans cinerea*, *Carya*, *Ostrya*, *Ulmus*, *Celtis*, *Morus*, *Asimina*, *Platanus*, *Acer*, *Negundo* and lianes. — The Swamp Oak Facies consists of *Quercus palustris*, *Q. platanoides*, *Q. macrocarpa*. The floor of these forests has the usual lowland vegetation, such as *Arisaema dracontium*, *Claytonia virginica*, *Dentaria laciniata*, *Viola cucullata*, *Osmorrhiza longistylis*, *Mertensia virginica*, *Commelina nudiflora* etc.

West of a line drawn from the northeastern corner of Missouri to the southwestern corner, we find a flora which represents a transition from the forests of the Mississippi valley to the flora of the prairie regions lying west[2]. The flora shows the presence of *Quercus alba*, *Q. macrocarpa*, *Q. obtusiloba* and here in the extreme limit of *Fraxinus quadrangulata*, *Carpinus americana*, *Alnus serrulata*, *Cornus florida*. Here also *Sassafras*, *Juglans cinerea*, *Betula nigra*, *Tecoma radicans* reach their western limits.

We do not find Quercus alba, Q. bicolor (= Q. platanoides), Q. imbricaria, west of a line that represents the western boundary of Missouri. West of this line only three oaks remain, viz: Quercus macrocarpa, Q. rubra and Q. palustris, Juglans nigra, Platanus occidentalis, Negundo aceroides (= Acer negundo), Populus monilifera (= P. deltoides), Acer dasycarpum (= A. saccharinum), Celtis occidentalis, Ulmus fulva, Cercis canadensis, which occur in eastern Kansas in considerable bodies, but finally restricted to the valleys preceding toward the west, where the trees become greatly reduced in size or stunted. At this point the treeless prairies are reached that begin to appear as features of the landscape in western Missouri. Wherever the limestone approaches the surface of the prairies in this neighborhood occur Desmanthus brachylobus, Helianthus orgyalis.

The forest trees which border the prairies in eastern Missouri are chiefly Quercus alba, Q. stellata, Q. tinctoria, Q. Muhlenbergii and an occasional tree of Platanus occidentalis. Between the forest and the prairie vegetation is found a thicket consisting of Rhus glabra, Sambucus canadensis, Euonymus atropurpureus, Cercis canadensis, Rhamnus lanceolata, Pirus (Malus) coronaria, Cornus asperifolius, together with an undergrowth of Rosa arkansana, R. blanda, R. humilis, Rubus canadensis, R. occidentalis, R. villosus. The lianes are Vitis riparia, Celastrus scandens, Menispermum canadense, Smilax ecirrhata, S. berbacea, S. bispida and the poison ivy Rhus toxicodendron. This thicket is fringed on the prairie side with low-growing shrubs (Ribes gracile,

1) MACKENZIE, KENNETH K.: Manual of the Flora of Jackson County, Missouri. 1902. p. V.

2) BROADHEAD, G. C.: Geographical Distribution of certain Trees and Plants in Missouri and Kansas. Kansas City Review of Science and Industry III: 608.

Rhus canadensis, Symphoricarpos), while between this shrubby fringe and the prairie vegetation grow in Spring many herbs.

The forest of the Ozark Plateau extends into Indian Territory (now part of the State of Oklahoma). The timber is most compact along the Arkansas border and as a rule where the contour lines show the elevation to be greatest, although here as in other portions, the river-bottom lands are heavily and densely wooded. The forest consists of oaks: *Quercus marylandica* (blackjack), *Q. obtusiloba* (post oak), *Juglans nigra*, *Quercus alba*, *Juniperus virginiana*, *Fraxinus americana*, *Carya olivaeformis* (= *Hicoria pecan*), *Populus monilifera*, *Maclura aurantiaca*, *Platanus*, *Ulmus*, *Celtis*, *Robinia*, *Betula nigra*, *Bumelia lanuginosa*. Loblolly pine (*Pinus taeda*) is found only in the mountainous portion of the eastern portion, its range being confined to a limited area. It grows with other trees and is nowhere abundant [1].

The forests in the western part of the late Indian Territory may be considered to be a part of that mentioned below extending through Texas, Indian Territory and Oklahoma into southern Kansas and known as the »Cross Timbers«. The Wichita Mountains of Oklahoma may be considered as a northern extension of the upper Cross Timbers. The characteristic tree of this region is *Quercus obtusiloba* (= *Q. minor*). The mountain sides are clothed with three species of oaks almost to the exclusion of other species, namely, *Quercus obtusiloba*, *Q. falcata* (= *Q. digitata*) and *Q. texana*. The creek valleys at the base of these mountains contain some fine specimens of Mexican walnut, *Juglans rupestris*.

Other species here are: Ulmus americana, U. alata, U. fulva, Diospyros virginiana, Gymnocladus canadensis (= G. dioica), Populus monilifera, Celtis occidentalis, Negundo aceroides (= Acer negundo), Juniperus virginiana, Sapindus Drummondii, Cercis canadensis, Rhus cotinus (= Cotinus cotinoides). Near the western boundary of Oklahoma this forest fades out into a scattering growth of Populus monilifera, Celtis occidentalis, Ulmus americana, Prosopis juliflora, Carya olivaeformis (= Hicoria pecan), Quercus obtusiloba [2]. Growing on sandy or rocky soil of the uplands are found many oaks but more especially Quercus obtusiloba, Quercus marylandica, and in the river bottoms Juglans nigra, Populus monilifera, Carya olivaeformis (= Hicoria pecan), Ulmus americana, Acer sp., etc.

The southern extension and limit of the deciduous forest of the Ozark Area is to be looked for in Texas where two forks of the forest (see map) extend almost to the Rio Grande River. The upland timber in Texas in the lignitic belt, where sandyclay ridges and hills prevail, consists mainly of oak, extending far into the Rio Grande plain [3]. Other belts of this timber are isolated from the main forest and are open savanna forests. The upper

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1) Fitch, C. H.: Woodland of Indian Territory. U. S. Geological Survey 21st Report. 1900. Part V.: 609.

2) Clothier, George L.: Silvicultural Possibilities of the Prairies. Forestry and Irrigation IX: 89—90. Feb. 1903.

3) Bray, William L.: Forest Resources of Texas. U. S. Bureau of Forestry Bulletin 47 (1904). 26. The Timber of the Edwards Plateau of Texas, U. S. Bureau of Forestry Bulletin 49 (1904): 19—20.

and lower Cross Timbers are of this type. — The open forests of the granite region of the Carboniferous area and of the isolated gravel terraces as those above the Colorado River at Austin, where on the picturesque banks of this river grows *Carya olivaeformis* (*Hicoria pecan*), *Populus monilifera*, *Platanus*, *Quercus virginiana* (*Q. virens*), *Q. rubra*, *Q. nigra*, *Q. macrocarpa*, *Q. palustris*, *Sapindus Drummondii* and *Juniperus virginiana*. Beyond the Neuces River, the post oak formation loses its identity. *Quercus marylandica* and *obtusiloba* constitute the chief elements in this type of forest, the post oak (*Q. obtusiloba*) forming the more abundant and larger growth.

## 2. Rock Cliff Formations.

On wet and dripping rocks, the vegetation forms an association of species that may be designated the Fontinal Association. Here occur the walking fern *Camptosorus rhizophyllus*, liverworts *Conocephalus conicus*, *Grimaldia rupestris* and *Dumortiera hirsuta*. A few phanerogams are found. These plants occupy the lowest portions of such dripping rocks. Above them grows an association of ferns *Cystopteris bulbifera*, *C. fragilis*, *Woodsia obtusa*, *Asplenium platyneuron*, *Nephrodium acrostichoides* and such flowering plants as *Arabis laevigata*, *A. dentata*, *A. canadensis* and *Erigeron philadelphicus*. The next association of plants occupies the upper portion of wet cliffs, or often whole sides of low moist cliffs. The crevices and cracks of the rocks accomodate *Aquilegia canadensis* and *Solidago Drummondii* while the ferns *Woodsia*, *Cystopteris fragilis*, *Pellaea atropurpurea*, *P. dealbata* (very rare), *Cheilanthes lanuginosa* occupy such situations. The summit edge of the cliff usually very dry and sterile is characterized by *Androsace occidentalis*, *Draba cuneifolia*, *Scutellaria campestris* and *parvula*, *Astragalus distortus*, *Carex setifolia*, *Arenaria texana*, *Allionia hirsuta*[1]).

The forest of the cliff summits that occupies the verge of the cliffs along the Missouri is dominated by Quercus acuminata, Q. minor (= Q. obtusiloba), Q. marylandica, Acer saccharum, Fraxinus quadrangulata, Carya alba (= Hicoria ovata), C. amara (= Hicoria minima), Diospyros virginiana, Juniperus virginiana, Amelanchier canadensis, Celtis occidentalis, Ostrya virginiana, Cornus asperifolia, C. Drummondii, Viburnum rufotomentosum, Morus rubra, Vaccinium vacillans (south of Grindstone Creek), Mentzelia oligosperma (along cliffs of the Missouri River). The characteristic herbs are Solidago Drummondii, S. radula, S. speciosa, Aster anomalus, A. turbinellus and A. oblongifolius.

The cliffs along the Mississippi River, according to Hus, are almost perpendicular and sometimes even concave with soil in the numerous crevices of the rock faces. The plants of the spring flora which chiefly occur as rosette-forming annuals are Arabis canadensis, Draba cuneifolia, Erysimum asperum, Lechea major, Silene antirrhina, Astragalus mexicanus, Polygala verticillata, Heuchera hispida, Androsace occidentalis, Phlox pilosa, Lithospermum canescens, Monarda Bradburiana, Scutellaria parvula, and such grasses as Melica diffusa, Panicum depauperatum. At this time Eryngium yuccaefolium, Agave virginica, Verbascum thapsus enlarge their

1) Consult WARMING, Eug.: Oecology of Plants 1909: 239—247 for details as to the adaptations of rock plants, etc., and compare HARSHBERGER, J. W.: The plant Formations of the Nockamixon Rocks, Penna. Bulletin Torrey Botanical Club XXXVI: 651—673.

rosettes. The chief moss is Gymnostomum curvirostre, the lichens are Parmelia capitata, Physcia stellaris and Peltigera rufescens and the ferns are Cheilanthes lanuginosa, Pellaea atropurpurea, Woodsia obtusa. During the summer the cliff flora is augmented by Hypericum maculatum, Linum virginicum, Pimpinella integerrima, Sporobolus asper, Aster oblongifolius, A. novae-angliae, Solidago Drummondii, S. ulmifolia. The top of the bluff is occupied mainly by Panicum depauperatum, Androsace occidentalis, Rudbeckia hirta, Desmodium marylandicum, D. paniculatum, Psoralea tenuiflora, Stylosanthes elatior, (= S. biflora) and in patches the lichen Cladonia fimbriata.

*Prairie Formation.* In the vicinity of Columbia, Missouri, according to DANIELS, true prairies are represented only by a thin ribbon of vegetation about the summits of cliffs, upon the tops of hills and bluffs or in open thickets. It is, therefore, a portion of the true prairie flora that is interdigitated with the forest formations of the Ozark Area and in a soil of such slight depth that trees and shrubs can find no foothold, this remnant of a prairie flora leads a precarious existence. The most successful plant in the struggle is *Schrankia (Morongia) uncinata.* The cliff prairie grasses are *Andropogon furcatus, Chrysopogon avenaceus, Panicum virgatum* (rare), *Bouteloua racemosa, Agropyrum spicatum* (rare).

# Chapter III. North American Temperate Zone: Xerophytic Section of the Interior.

## 1. Prairie Region.

The origin of the American prairies has long been a favorite theme for discussion among physiographers and botanists. The general concensus of opinion has been that fires have played a prominent part in their formation. Other theories advanced have had adherents, the cause of prairies being traced to the fineness of the loess, the direction of the strong prevailing southwest winds, inimic to tree growth; the occupancy of a recent submerged area by grass vegetation after the recession of the water; the peculiar chemic character of the soil; the character of the climate; the underlying geologic formations, rainfall, etc.[1]). It seems, however, to the writer that none of these theories adequately express the reason for the origin of prairies, but that the explanation is to be sought in phytogeography, not in geology, meteorology, etc. The soil, the climate, the underlying geologic formations are all favorable to tree growth. The prairie soils, however, originating as loess, were at once tenanted by grass vegetation, because in proximity in nearby plant formations.

1) For theories proposed, see the following: WHITNEY, J. D., Plain, Prairie and Forest, American Naturalist X: 577, 656; CHRISTIE, MILLER, Why are Prairies Treeless. Proceedings Royal Geographical Society new ser. 1893, XIV: 78—100. MEEHAN, THOMAS: Treeless Prairies, Botanical Gazette VI: 253. TODD, J. E.: Distribution of Timber and Origin of Prairies in Iowa. American Naturalist 1878. XII: 91. HAY, O. P.: An Examination of Prof. LEO LESQUEREUX's Theory of the Origin and Formation of Prairies, American Naturalist, 1878. XII: 299.

Once a prairie soil was formed, trees were unable to encroach upon it, except where by erosion in the stream valleys the dense turf was broken, or at the base of cliffs, and elsewhere, where loose talus, or stony ground prevented the grass vegetation from making a close mat.

The experience of orchardists and farmer tree planters in the prairies has demonstrated that the eastern trees, on good soil cannot compete singly with the prairie grasses, no matter how great a supply of moisture is furnished either by rainfall or irrigation. HARVEY[1]) suggests that it is the absence of soil fungi that constitute the mycorrhiza upon which the forest trees depend for food supply, the difficulty of seed germination in a dense sod and finally prairie fires that account for the preservation of the typic grass-land formations against the encroachment of trees. There is only one way in which eastern trees may conquer the prairie grasses and that is by advancing in solid phalanx. This method of encroachment is necessarily very slow and accounts for the lack of time since the glacial epoch for the trees to extend their supremacy over the whole prairie region. Another cause that operated in the past to prevent trees from extending into the prairies was the presence of millions of buffaloes in the region. The buffalo severely grazed the grasses and kept them in close mats. The buffaloes likewise attracted the Indians, who set fire to the grass, thus confining the trees to the river banks, mountains and broken lands. With the settlement of the country, the other external factors remaining unchanged, as before, the cultivation of the ground and the destruction of the graminaceous plants with deeply penetrating matted fibrous roots permitted the trees and shrubs to gain ground upon a territory formerly covered with prairie plants. In a former page (p. 235), we have given some of the proofs of this kind of invasion. A prairie is a heavily grassed area (a closed formation), destitute of forest growth, but existing in the midst of a wooded region, where the climatic conditions are favorable to the growth of timber, but where on account of the exclusiveness of the grasses and their success against all competitors coupled with ecologic, physiographic, edaphic and historic influences rather than want of water and soil conditions the spread of forest trees has been prevented.

The boundaries of the prairie region cannot be given in an abbreviated statement. The map will show the approximate location of this grassy country. Phytogeographically this region is made to comprise the great plains, as well, as the prairie region proper, notwithstanding that this may be a violation of the views of some eminent phytogeographers, who would separate the two as quite distinct floristically considered. Turf-forming plants are the most important vegetation-form for the characterization

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1) Floral Succession in the prairie-grass Formation of southeastern South Dakota. Botanical Gazette XLVI: 81—108. According to experimental studies at Woburn Fruit Farm, a grass sod is injurious to fruit trees through an active poison resulting directly or indirectly from the growth of the grass. See LIVINGSTON, BURTON E., Studies on the Properties of unproductive Soils; Bulletin 36. U. S. Bureau of Soils 1907: 10—14.

of the prairies. — Of the thirty three species of grasses which compris the facies and the principal species of the prairies, according to POUND an CLEMENTS, Nebraska, Kansas and the Dakotas possess the entire number the prairies of Saskatchewan, Assiniboia and Manitoba possess 30 species, th Red River country 29 species, and the southern prairies 31 species. C 140 species most important with respect to frequence, abundance or charac teristics 83 are spread throughout the entire region, while 129 are found through out the central and southern portions, and 91 throughout the central an northern portions. The following plants are proper to the prairie formation

Acerates viridiflora Raf. var. Ivesii Britton.
» viridiflora var. linearis A. Gray.
Agrostis hiemalis Walt. (= A. scabra Willd.).
Allionia ovata Pursh.
Amorpha canescens Pursh.
Andropogon furcatus Muhl.
» scoparius Michx.
Androsace occidentalis Pursh.
Anemone caroliniana Walt.
» cylindrica A. Gray.
Antennaria campestris Rydb.
Artemisia gnaphalodes Nutt.
Asclepias obtusifolia Michx.
» syriaca L. (= A. cornuti Dec.)
» tuberosa L.
» verticillata L.
Aster multiflorus Ait.
» oblongifolius Nutt.
» sericeus Vent.
Astragalus crassicarpus Nutt. (= A. caryocarpus Ker.).
Baptisia bracteata Ell. (= B. leucophaea Nutt.).
Bouteloua curtipendula Michx. (= B. racemosa Lag.).
Brauneria pallida Nutt.
Carex Meadii Dewey.
» pennsylvanica Lam.
Ceanothus ovatus Desf.
Comandra umbellata L.
Coreopsis palmata Nutt.
Delphinium carolinianum Walt. (= D azureum Michx.).
Eatonia obtusata Michx.
Eragrostis pectinacea Michx.
Erigeron ramosus Walt.
Euphorbia corollata L.
Gentiana puberula Michx.
Helianthus Maximiliani Schrad.
» scaberrimus Ell. (= H. rigidus Desf.).
Hieracium longipilum Torr.
Koeleria cristata L.
Kuhnistera candida Willd.
» purpurea Vent.
Kuhnia eupatorioides L.
Lespedeza capitata Michx.
Liatris (Lacinaria) scariosa L.
» » squarrosa L.
Linum sulcatum Riddell.
Lithospermum canescens Michx.
» angustifolium Michx. (= L. linearifolium Goldie).
Desmodium (Meibomia) illinoensis A. Gray.
Mesadenia (Cacalia) tuberosa Nutt.
Prenanthes (Nabalus) asper Michx.
Onosmodium molle Michx.
Oxalis violacea L.
Panicum depauperatum Muhl.
» pubescens Lam.
» Scribnerianum Nash.
Phlox pilosa L.

Physalis heterophylla Nees.
» virginiana Mill.
Polygala verticillata L.
Psoralea argophylla Pursh.
» esculenta Pursh.
» tenuiflora Pursh.
Rosa arkansana Porter.
Ruellia ciliosa Pursh.
Salix humilis Marsh.
Senecio plattensis Nutt.
» integerrimus Nutt.
Silphium laciniatum L.
Sisyrinchium angustifolium Mill.
Solidago nemoralis Ait.
» rigida L.
» rigidiuscula T. & G.
» rupestris Raf.
Sporobolus asper Michx.
» heterolepis A. Gray.
Stipa spartea Trin.
Verbena stricta Vent.
Vernonia gigantea Walt.
» fasciculata Michx.

The vegetation center of the prairies is found in Nebraska, Iowa, Kansas and the Dakotas[1]). From this center, the typic plains flora slowly shades out toward both south and north. The prairie region naturally separates itself into several districts; Transition Prairie Forest District; Prairie District; Sand Hill District; Foothill District. The prairies and sandhills being in close conjunction and only edaphic modifications are to be united in the same paragraph (B.).

## A. Transition Prairie-Forest District.

The passage from the heavily wooded region of the north and east into the treeless plains of the west is a gradual one and the disappearance of the underwood and the predominance of oak openings, or groves of oak and other forest trees, not crowded together, but scattered over the surface at a considerable distance apart without any low shrubs or underbrush is the characteristic appearance of the prairies in Illinois, eastern Iowa, parts of Wisconsin and Minnesota and in fact along the eastern border of the prairies where they abut upon the eastern deciduous forests[2]).

### 1. The forests of the Transition District.

Throughout the central part of Illinois, the prairie represents the most primitive plant formation which has been invaded by a forest along the drainage lines where the succession of plant associations is hastened by the change in soil and topography due to stream action. As there are no water courses

1) Pound, Roscoe and Clements, Frederic E.: The Vegetation Regions of the prairie Province. Botanical Gazette XXV: 384. June 1898; and the important papers by Hitchcock, A. S., Ecological plant Geography of Kansas; Transactions of the Academy of Science of St. Louis (1898) VIII: 55—69 and Gleason, H. A., Some unsolved Problems of the Prairies; Bulletin Torrey Botanical Club XXXVI: 265—271.

2) Pammel, L. H.: A comparative Study of the Vegetation of swamp, clay and sandstone Areas in western Wisconsin, southeastern Minnesota, northeastern, central and southeastern Iowa. Proceedings Davenport Academy of Science X: 32—126. 1905.

running through the sand prairies the encroachment of the forest has been slow. The first tree-growth that invades the sand prairies is a xerophytic association composed mainly of the black-jack oak *Quercus marylandica* and usually known as black-jack timber. Besides the oak, which constitutes about 50 per cent of the forest, there is about 35 per cent of the black oak. *Quercus tinctoria* (= *Q. velutina*) and 15 percent of the hickory *Carya odorata* (= *Hicoria microcarpa*). The trees seldom exceed a foot in diameter, and they are generally very crooked, gnarled and full of dead branches. The hickory is nearly always sterile, only the largest trees producing fruit.

The undergrowth, according to C. A. HART and H. A. GLEASON[1]), consists of young trees of the above species and Rhus aromatica, Amorpha canescens and Salix tristis. In the edge of the woods prairie bunch grasses occur while in the denser shade of the trees are found Panicum cognatum, Triodia cuprea (= Tricuspis seslerioides), Eragrostis trichodes (= E. tenuis), Paspalum setaceum and Andropogon furcatus, all these grasses in bunches few and wide apart. The remainder of the flora is characterized by Callirhoe triangulata, and Tephrosia virginiana, which is extremely abundant and grows in dense patches ten feet or more in diameter together with Opuntia humifusa (O. mesacantha), Oxybaphus (Allionia) nyctaginea, Cassia chamaecrista, Froelichia campestris, Helianthus occidentalis, Helianthemum majus. The soil in which the trees and herbs grow is a pure sand and the formation of leaf mold goes on very slowly. With the first traces of leaf mold there appear Aquilegia canadensis, Silene stellata, Anemone virginiana, Agrimonia mollis and later as the soil deepens are found Smilacina (Vagnera) racemosa, Eupatorium ageratoides, Geum canadense and Asclepias exaltata with scattering trees of Cercis canadensis, Morus rubra and Celtis occidentalis.

*Oak Grove Formation.* In eastern Iowa and elsewhere the oak groves are remarkable for the paucity of large trees, but wherever they occur, their composition varies. Sometimes one species predominates and sometimes another, so that they receive the distinctive names of white oak, bur oak, or so called black oak groves. For example one grove consisted of *Quercus coccinea* which predominated with *Quercus rubra* and *Q. macrocarpa*, *Q. alba* as subordinate species, and occasionally *Q. Muhlenbergii* (= *Q. acuminata*) and *Q. tinctoria*. In southern Iowa *Q. marylandica* becomes the dominant tree and elsewhere *Q. prinoides*, *Q. obtusiloba* (= *Q. minor*) the post oak, which occurs sparingly in the southern groves[2]). In Wisconsin[3]) the oak openings consist of *Quercus alba*, *Q. rubra*, *Q. coccinea*, *Juglans cinerea*, *Corylus americana* with such herbs beneath as *Anemone nemorosa*, *Lupinus perennis*, *Baptisia leucophaea*, *Monarda fistulosa*, while such herbs, as *Linaria canadensis*, *Oenothera rhombipetala*, *Aster multiflorus*, *A. oblongifolius*, *Arctostaphylos uva-ursi*, *Castilleia sessiliflora* are transitional between the oak openings and the undulating prairie above the Wisconsin River.

This formation in Oklahoma and Texas corresponds to the open savanna forests of the Cross Timbers described as a prolongation of the deciduous forest into Texas. With much pro-

1) Bulletin Illinois State Laboratory of Natural History VII: 171—178. January 1907.

2) FITZPATRICK, T. J. and M. F. L.: The native oak Groves of Iowa. Plant World IV: 69. April 1901.

3) LUEDERS, HERMAN F.: The Vegetation of the Town Prairie du Sac. Transactions Wisconsin Academy Sciences, Arts and Letters X (1894-95): 510.

priety such timber might have been described as an oak opening and the description included here, but as a border forest extending into the prairie and of a greater extent territorily than the oak groves in Illinois and elsewhere, it was thought better to consider them as a part of the Ozark deciduous forest Area. (See ante Chapter II. § 3. C. c.)

The principal trees of the deciduous forests in the upper Mississippi basin proper are *Quercus alba*, *Q. coccinea*, *Q. tinctoria*, *Q. rubra*, *Q. macrocarpa*, *Q. bicolor* (bottom-land), *Q. Muhlenbergii*, *Acer dasycarpum*, *A. rubrum* (on sandy, black loam), *Carya porcina* (= *Hicoria glabra*), *Juglans cinerea*, *J. nigra*, *Populus monilifera* (in bottoms). The trees of the dry ridges are *Betula papyrifera*, *Carya alba* (= *Hicoria ovata*), *Quercus alba*, *Q. macrocarpa*, *Gymnocladus canadensis* (*dioica*), *Prunus virginiana*, *Juniperus virginiana*, *Tilia americana* and *Celtis occidentalis*. These are the trees between Trempealeau, Wisconsin and Dubuque, Iowa: *Betula papyrifera*, *B. nigra*, *Juglans cinerea* are more abundant north of this territory. The sycamore *Platanus occidentalis*, *Gleditschia triacanthos*, *Gymnocladus*, *Juglans nigra*, *Quercus Muhlenbergii* and *Morus rubra* are southern trees which have moved north along the great river [1]).

The herbs of these moist woods in the upper Mississippi Valley are Actaea alba, A. rubra, Adiantum pedatum, Aralia nudicaulis, A. racemosa, Arisaema triphyllum, Asarum canadense, Dicentra cucullaria, Caulophyllum thalictroides, Hepatica acuta (= H. acutiloba), Hydrophyllum virginicum, Liparis liliifolia, Podophyllum peltatum, Pedicularis canadensis, Viola pubescens, etc. The phytogeographer is led to believe that this forest formation is an intrusion into the prairie region of one typic of the mesophytic forest region of Piedmont-Appalachian-Ozark type.

The forest of this transition territory occupies three distinct types of physiography, viz: ridges and hill slopes, rock ledges and alluvial bottom-land. Each physiographic area is characterized by a distinct phytogeographic formation.

*Ridge and Hill Slope Forest Formation.* The most conspicuous trees on the flat slopes are *Quercus alba*, *Q. rubra*, *Q. tinctoria*, *Carya alba* (= *Hicoria ovata*), *Populus tremuloides*, *P. grandidentata*, *Tilia americana* (occasional), *Ostrya*, *Carpinus*, *Fraxinus sambucifolia*. — The most conspicuous trees of the upper slopes are *Betula papyrifera*, *Carpinus caroliniana*, *Ostrya virginiana*, *Tilia americana*, *Juglans cinerea*. The lower sunny clay slopes were in early times covered with *Quercus macrocarpa* and *Q. tinctoria*, the former species predominating in Wisconsin and Minnesota. The shaded slopes were characterized by *Quercus alba*, *Q. rubra*, *Pirus ionensis*, *Prunus americana*, *P. virginiana*, *Corylus americana*.

*Alluvial Bottom Forest Formation.* The higher alluvial soils are characterized by *Acer dasycarpum*, *Tilia americana*, *Ulmus americana*, *Populus monilifera*, *Quercus rubra*, *Carya amara* (= *Hicoria minima*), *Fraxinus viridis* and occasionally *Juglans nigra*. The absence of *Betula nigra* and *Quercus bicolor* (= *Q. platanoides*) is noteworthy.

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1) PAMMEL, L. H.: Forest Vegetation of the upper Mississippi. Garden and Forest IV: 460, 472, 531.

The alluvium of the Mississippi consists of detached sandy prairies in places not always covered by water. In other places are found[1]) Acer saccharinum, Ulmus americana, Betula nigra, Populus monilifera, Quercus bicolor, Fraxinus viridis, occasionally Quercus rubra and near the mouth of Root River Morus rubra and Gymnocladus canadensis (= G. dioica). — The flora of the flood plain of the Iowa River consists of Acer dasycarpum, Negundo aceroides (= Acer negundo), Ulmus racemosa, U. americana, Fraxinus viridis, Populus monilifera while on the second shore line occur Acer nigrum, Juglans nigra, J. cinerea, Ulmus fulva, U. americana, U. racemosa, Carya amara (= Hicoria minima), Quercus macrocarpa, Q. rubra, Crataegus mollis, C. punctata, Pirus (Malus) ioensis, Prunus americana. — The vegetation of the Des Moines alluvium is somewhat similar. Here occur Acer dasycarpum, Negundo aceroides, Ulmus americana, Fraxinus viridis, Populus monilifera, Salix amygdaloides, S. nigra, S. longifolia and under the tree shade Leersia virginica, Elymus virginicus, Panicum crus-galli, Pilea pumila, Bidens frondosa, Vernonia fasciculata, Aster Tradescanti, Nasturtium (Roripa) palustre, Cinna arundinacea and Spartina cynosuroides. Platanus occidentalis is absent from the Des Moines alluvium.

*Rocky Ledge Forest Formation.* Along the upper slopes of the St. Croix sandstone ledges occur *Pinus Strobus*, *Taxus canadensis*, *Betula lenta*, while close to the springs *Alnus incana* occurs.

On these ledges grow such plants as Phegopteris dryopteris, P. polypodioides, Lycopodium lucidulum, Asplenium filix-foemina, Nephrodium (Dryopteris) spinulosum var. dilatatum, Pellaea gracilis, Mitella diphylla and along the Kickapoo, Sullivantia procumbens, Circaea alpina, Cornus circinata, Arabis nudicaulis, A. racemosa, Acer spicatum, Oenothera fruticosa and Aquilegia canadensis.

On rocky talus the botanist finds such trees as Pinus Strobus, Betula papyrifera, B. lenta, Juglans cinerea, Quercus rubra (occasionally), Acer nigrum, Juniperus virginiana, and shrubs, Amelanchier canadensis, Coruus circinata, Diervilla trifida. Along Pine Creek beneath the trees are Osmunda Claytoniana, Cornus circinata, Diervilla trifida, and Cypripedium spectabile. Where sufficiently weathered the sandstone ledges are characterized by Populus grandidentata, Quercus rubra, Quercus alba, Q. Muhlenbergii (= Q. acuminata), Juniperus virginiana, Acer nigrum, Cornus circinata, C. alternifolia, Viburnum pubescens, Rhamnus lanceolata and such herbs as Thalictrum dioicum, Lathyrus venosus, L. ochroleucus, Asarum canadense, Cypripedium pubescens, Trillium nivale, Aralia nudicaulis, A. racemosa, Monarda fistulosa and Eupatorium ageratoides.

## 2. The Prairie- and Cliff Formations.

*Prairie Grass Formation.* In central Illinois[2]) in the oak opening territory two kinds of prairie may be distinguished viz: wet and dry.

The first plants blooming in the spring on the dry prairies are Draba caroliniana, Anemone decapetala, Ranunculus fascicularis, Oxalis violacea, Androsace occidentalis; in May, Lithospermum angustifolium (= L. linearifolium), L. canescens, L. hirtum (= L. Gmelini), Troximon cuspidatum, Baptisia leucophaea, Pentstemon pubescens (= P. hirsutus); in June, Viola delphinifolia, Scutellaria parvula, Linum sulcatum, Polygala incarnata, P. sanguinea (= P. viridescens), Asclepias Meadii, A. obtusifolia, Sisyrinchium bermudianum, Tradescantia virginica, Silene antirrhina, Mesadenia (Cacalia) tuberosa; in July, Silphium laciniatum, S. terebinthinaceum, S. integrifolium, Echinacea angustifolia, Coreopsis palmata, C. lanceolata, Rudbeckia hirta, R. subtomentosa, Lepachys pinnata, Asclepias tuberosa, A. verticillata, Euphorbia corollata, Petalostemon violaceus (= P. purpureus), P. candidus, Amorpha canescens, Desmodium illinoense, Ruellia ciliosa, Callirhoe triangulata, Potentilla arguta, Eryngium yuccaefolium (E. aquaticum); in August, Heli-

1) Pammel, L. H.: loc. cit.
2) Brendel, Frederic: Flora Peoriana. 1887: 34.

anthus rigidus (= H. scaberrimus), H. occidentalis, Solidago rigida, S. missouriensis, Hieracium longipilum, Diplopappus linariifolius, Liatris cylindracea, L. scariosa, L. pycnostachya, Prenanthes (Nabalus) aspera, Gnaphalium polycephalum (= G. obtusifolium), Chrysopsis villosa; lastly in September, Aster sericeus, A. azureus, A. oblongifolius, A. multiflorus, A. ericoides and Gentiana puberula.

The grasses of dry prairies are *Chrysopogon nutans*, *Andropogon furcatus*, *A. scoparius*, *Koeleria cristata*, *Eatonia obtusata*, *Elymus canadensis*, *Stipa spartea* and *Sporobolus heterolepis*. The flora of such prairies in Wisconsin is peculiarly uniform, because the following grasses predominate: *Andropogon furcatus*, *A. scoparius*, (see Fig. 27) *Chrysopogon nutans*,

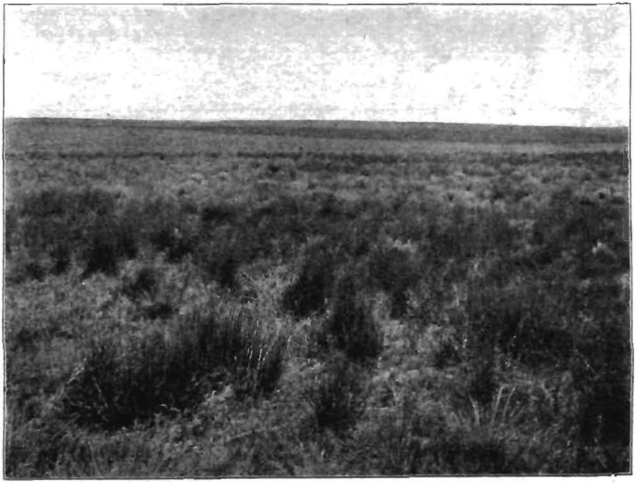

Fig. 27. Bunch-grass Formation. Andropogon scoparius Michx. together with Artemisia filifolia Torr. and the short grass Bouteloua hirsuta Lag. Photograph by Dr. H. L. SHANTZ with permission United States Department of Agriculture.

*Sporobolus asper*, *Bouteloua hirsuta* and *Festuca tenella*. In depressions twenty feet below the general surface occur *Agrostis scabra* (= *A. hiemalis*), *A. perennans*, *Asclepias cornuti*, *Viola pedatifida*, *Ranunculus rhomboideus*.

The prairies in the neighborhood of Chicago near Lake Michigan have had a swamp or lake origin. Aquatic floating plants such as, *Riccia*, *Potamogeton*, *Brasenia* are supplanted by bulrushes, *Scirpus lacustris*, *Typha*, *Pontederia*, *Sparganium*, *Sagittaria*, *Zizania*, *Phragmites*, *Acorus calamus* and *Eriophorum cyperinum*. Sedges later encroach on these plants as the new soil

becomes raised more and more above the lake and grasses follow the sedges forming a prairie. Sometimes with the prairie grasses are a number of coarse herbs *Silphium laciniatum*, *S. terebinthinaceum*, *S. integrifolinm*, *Solidago rigida*, *Allium cernuum* [1]).

The flora of the wet prairies in Illinois is mixed with the species of the neighboring banks, swamps and bottom-woods and differs according to the soil. Tall grasses such as Calamagrostis canadensis, Leersia (Homalocenchrus) lenticularis, Spartina cynosuroides abound mixed with sedges as Scirpus, Cyperus, Carex vulpinoidea, C. crus-corvi, C. stipata, C. conjuncta, C. scoparia, C. straminea, C. hystricina. The most conspicuous herbaceous plants of the spring are: Menyanthes trifoliata, Camassia esculenta, Allium canadensis; of the summer, Phlox glaberrima, Asclepias Sullivantii, Saxifraga pennsylvanica, Steironema lanceolata, Ipomoea lacunosa, Habenaria leucophaea; of the autumn, Boltonia asteroides, Prenanthes (Nahalus) racemosa, Solidago neglecta, S. Ridellii, S. ohioennis, Helianthus giganteus, Gentiana Andrewsii and Polygonum ramosissimum.

The grassy slopes in the St. Croix country where the soil is brownish, or blackish, are covered by Bouteloua curtipendula, Andropogon scoparius, Koeleria cristata, and such early flowing herbs as Viola pedatifida, V. pedata, Arabis lyrata, Phlox pilosa, Silene anitirrhina, while later in the season appear Ceanothus americanus, Delphinium azureum (= D. carolinianum), Solidago rigida, S. nemoralis and Rosa blanda.

The flora of the Wisconsin drift consists of the characteristic prairie vegetation including species of Liatris and Andropogon, accompanied by Phlox pilosa, Panicum Scribnerianum, P. virgatum, Vicia americana, Geranium maculatum, Echinacea purpurea, Lithospermum canescens, L. angustifolium, Viola palmata, V. pedata, Castilleia sessiliflora, Astragalus caryocarpus (= A. crassicarpus), Stipa spartea, etc. Polytaenia Nuttallii, Ceanothus ovatus, Baptisia leucophaea, Rudbeckia hirta, Oenothera serrulata. The plants of the lower and flat areas are: Anemone pennsylvanica, Thalictrum purpurascens, Juncus tenuis, Panicum Scribnerianum, P. virgatum, Liatris scariosa, L. pycnostachya, Vicia americana, Baptisia leucantha, Lilium philadelphicum, L. canadensis, Lathyrus venosus and Cicuta maculata [2]).

Sand Prairie Formation. The plant associations of the sand prairies are three: the bunch-grass, the blow-sand and the blow-out associations. The Bunch Grass Association (see Fig. 27) is characterized by *Eragrostis trichodes*, *Stipa spartea*, *Panicum cognatum* in dense flat bunches scarcely a foot high, *Triodia cuprea* (= *Tricuspis seslerioides*), *Calamagrostis* (*Calamovilfa*) *longifolia*, *Eragrostis pectinacea*, *Bouteloua hirsuta*, *Panicum virgatum*, *Paspalum setaceum* and *Sporobolus cryptandrus* also produce more or less well-developed bunches. Here also occur *Carex gravida*, *Cyperus Schweinitzii* and *C. filiculmis*.

The Blow-Sand Association occurs where the wind causes a shifting of the sand, which if excessive remains without vegetation. The mat-like *Opuntia humifusa*, the dense clumps of *Amorpha canescens* or *Chrysopsis camporum* may be effectual in anchoring such drifting sand. The most typical plants of this association are *Ambrosia psilostachya*, *Cassia chamaecrista*, *Cenchrus tribuloides*, *Cycloloma atriplicifolium* (= *C. platyphyllum*), *Cristatella Jamesii* and *Aristida tuberculosa*. The vegetation of the front of an advancing dune is different from that of the blow-sand association.

1) See Cowles, H. C.: Physiographic Ecology of Chicago and Vicinity. Botanical Gazette XXXI: 155 Feb. and March 1901.

2) Pammel, L. H.: Comparative Study of Vegetation, etc. loc. cit.

The Blow-out Association exists where the wind has scooped out hollows in the sand and an entirely new set of plants occupies the ground. *Fimbristylis capillaris* first appears and forms a carpet over the flat bottom of the blow-out, ultimately forming a thin layer of black humus over the surface. Associated with it are large clumps of *Panicum virgatum*, and *Andropogon furcatus*. With these grasses are often associated *Vitis vulpina*, *Menispermum canadense*, *Populus monilifera*, *Negundo aceroides*. The two vines scramble over the ground and the trees grow rapidly. Lichens of the genus *Cladonia* appear and are succeeded by *Helianthus occidentalis*, *H. rigidus* (= *H. scaberrimus*), *Liatris scariosa*, and *Cacalia atriplicifolia* [1]).

*Sand Prairie Formation.* These associations occur near the mouths of the principal rivers that are tributary to the northern Mississippi River in Wisconsin and elsewhere [2]). The only arboreous vegetation growing on these prairies are *Quercus macrocarpa*, *Q. tinctoria* and occasionally *Fraxinus viridis* and *Betula lenta*. These trees, however, occur only in close proximity to the Mississippi bottoms.

*Prairie Swamp Formation.* The marshes of the transition prairie-forest country are the sources of perennial springs, which if of sufficient size form small streams that are lined by *Salix discolor* and *S. Richardsonii*. Confined to the marsh edges are *S. candida*, *S. lucida*, while *Alnus incana* and *Cornus stolonifera* are characteristic shrubs.

The commoner plants of these marshes are Saxifraga pennsylvanica, Thalictrum purpurascens, Viola blanda, Iris versicolor, Glyceria nervata, Parnassia caroliniana, Lilium canadense, Pedicularis lanceolata, Lycopus sinuatus (= L. americanus), Mentha canadensis, Stachys palustris, Gentiana crinita, G. Andrewsii, Castilleia coccinea, Heracleum lanatum, Valeriana edulis, Cnicus (Carduus) muticus, Archangelica (Angelica) atropurpurea, Conium maculatum, Cardamine rhomboidea and Bromus Kalmii, while Cypripedium candidum, Caltha palustris, Viola blanda, V. canina var. Muhlenbergii (= labradorica) and Symplocarpus foetidus are local plants found in proximity to the springs.

The species of the larger open swamps in the prairie country of Illinois are: Epilobium palustre, E. coloratum, Proserpinaca palustris, Cicuta maculata, Sium cicutaefolium, Aster phoeniceus, A. novi-Belgii, A. junceus, A. salicifolius, A. paniculatus, Acorus calamus, Typha latifolia, Triglochin palustris, T. maritima, Dulichium spathaceum (= D. arundinaceum), Eleocharis palustris, Eriophorum gracile, Rhynchospora alba, Carex polytrichoides, C. teretiuscula, C. filiformis, C. comosa, C. riparia, C. monile, Muhlenbergia glomerata (= M. racemosa), Phragmites, Phalaris arudinacea, Nephrodium (Aspidium) thelypteris, Osmunda regalis.

The alluvial marshes along the sloughs of the Mississippi and Black Rivers are common and similar situations along the Wisconsin River support many herbs as Ranunculus multifidus (= R. delphinifolius), Sarracenia purpurea, Viola blanda, Stellaria (Alsine) longifolia, Hypericum mutilum, Potentilla palustris, Saxifraga pennsylvanica, Parnassia caroliniana, Lythrum alatum, Epilobium lineare, Cicuta bulbifera, Galium trifidum, Eupatorium perfoliatum, Boltonia asteroides, Aster novae-Angliae, A. Tradescanti, Coreopsis (Bidens) trichosperma, Campanula aparinoides, Gentiana Andrewsii, Menyanthes trifoliata, Chelone glabra, Veronica anagallis, Gerardia purpurea,

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1) C. A. Hart and H. A. Gleasom (loco citato).

2) Pammel, L. H.: Forest vegetation of the upper Mississippi. Garden and Forest IV: 460, 472, 531.

Pedicularis lanceolata, Scutellaria galericulata, Polygonum amphibium, P. sagittatum, Salix discolor, S. petiolaris.

*Cliff Formation.* On the banks of the thickly wooded bluffs of the upper Mississippi bold rocky ledges arise quite abruptly from the flood plain. The lower part of these ledges is sandstone, the upper magnesian limestone. *Arabis lyrata*, *Poa compressa* a few sedges and lichens occur on the limestone. The shaded gullies, however, reaching to the escarpments are tenanted by *Athyrium filix-foemina*, *Cystopteris fragilis*, *Osmunda Claytoniana*, *Adiantum pedatum*, *Onoclea struthiopteris* and *Pteris aquilina*. The sandstone outcrops are moist and occupied in places by *Pinus Strobus* with ferns. Such ferns as *Osmunda cinnamomea*, *O. regalis*, *O. Claytoniana* are at the base of the sandstone. *Camptosorus rhizophyllus* occurs on detached limestone blocks on the flood plain [1]. On the rocks of the St. Croix sandstone ledges grow *Woodsia obtusa*, *W. ilvensis*, *Melica mutica*, *Poa nemoralis*, *Arabis lyrata*, *Campanula rotundifolia*, *Danthonia spicata*, *Vaccinium pennsylvanicum*.

Of the many plants occuring on the dry ledges in this transition district attention may be called to Campanula rotundifolia, Danthonia spicata, Eragrostis capillaris, Lechea major (= L. villosa), Helianthemum canadense, Erigeron divaricatus, Draba caroliniana, while in shaded woods under sandstone ledges are found Trillium nivale, Viola pubescens, Isopyrum biternatum, Dicentra cucullaria and Anemone nemorosa. — The moist rocks and sandstone show the presence of Aralia racemosa, A. nudicaulis, Camptosorus rhizophyllus, Cornus circinata, C. alternifolia, Galium aparine, G. boreale, Phryma leptostachya, Rudbeckia hirta, Woodsia obtusa, Cystopteris fragilis, Fragaria vesca, Polypodium vulgare, Mitella diphylla, Actaea rubra, Prenanthes (Nabalus) alba, Amphicarpaea monoica, Thalictrum dioicum, and Teucrium canadense. — The open spaces on ledges between the forest trees in some places are covered with Cladonia sylvatica, Polytrichum juniperinum, Helianthemum canadense, Lechea major (= L. villosa), Danthonia spicata, Eatonia obtusata, Koeleria cristata, Euphorbia corollata, Petalostemon candidus and P. violaceus [2].

## B. Prairie- and Sand Hill District.

### a) The true Prairie Territory center.

The floral covering of the prairies corresponds to their physiography, and is essentially homogeneous. In many localities there is noticeable difference between the vegetation of low prairies and that of high prairies. The former are characterized by a more or less closed type, the latter by the open type of formation. The same facies, however, occur in both situations, and the change in aspect proceeds entirely from a difference in the secondary species. With reference to the constitution of the soil, prairie formations are of two kinds. 1. the prairie-grass formation found on loamy soils and 2. the buffalo-grass formation occuring on argillaceous soils, "gumbo" hills and plateaux.

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1) PAMMEL, L. H. and KING, CHARLOTTE, M.: Iowa Academy of Science IX (1902); 135.
2) PAMMEL, L. H.: Comparative Study of Vegetation, loc. cit.

*Prairie Grass Formation*[1]). The principal grasses of this formation are sod producers and the soil is therefore covered with a close turf. The facies are *Sporobolus asperifolius*, *Koeleria cristata*, *Eatonia obtusata* and *Panicum Scribnerianum*. In different localities plants of adjacent formations wander in and modify the constitution of the formation. For example *Stipa spartea* and *Panicum virgatum* enter from the meadow formation, *Aristida purpurea* from the beard-grass formation and *Buchloë* (*Bulbilis*) *dactyloides* from the buffalo-grass formation. *Bouteloua curtipendula* and *B. oligostachya* are important secondary species of great frequency here, as in all the grass formations. *Andropogon scoparius* and *A. furcatus* which are characteristic of certain other formations are of comparatively little abundance. *Agropyrum pseudorepens*, in low prairies becomes a bunch-grass. The important secondary species, however, are *Festuca ovina*, *Eragrostis pectinacea*, *Sporobolus asper*, *S. vaginiflorus*, *Agrostis hiemalis* and *Schedonnardus paniculatus*.

A vernal and an estival-serotinal aspect, according to POUND and CLEMENTS, are presented by this formation. The grassy covering in the spring is spangled with Draba caroliniana, Androsace occidentalis, Scutellaria parvula, Astragalus crassicarpus (= A. caryocarpus), Antennaria campestris, Peucedanum foeniculaceum, Carex pennsylvanica, Baptisia bracteata, Anemone caroliniana, Comandra umbellata. On low prairies the vernal species are Allium mutabile, Callirhoë alcaeoides, C. involucrata, Lithospermum angustifolium (= L. linearifolium) and Viola pedatifida. In the autumn, the prairie is brightened by Amorpha species of Solidago, Verbena, Trifolium, Aster, Liatris. Outside of the grasses the most characteristic plants are Amorpha canescens, Psoralea floribunda, Solidago rigida, S. rupestris, S. canadensis, S. rigidiuscula, S. speciosa, Verbena stricta, V. hastata, Kuhnistera purpurea, K. candida, Liatris scariosa, L. punctata, L. squarrosa, Aster multiflorus, A. sericeus and Vernonia gigantea (= V. altissima). These are plants of greater frequence. The widely distributed and scattered plants are: Cnicus (Carduus) undulatus, Achillea millefolium, Mesadenia (Cacalia) tuberosa, Prenanthes (Nabalus) asper, Gerardia purpurea, Potentilla arguta while Eriocarpum spinulosum, Hymenopappus flavescens, Yucca angustifolia (= Y. glauca), Cactus viviparus, Opuntia missouriensis (= O. polyacantha), Evolvulus pilosus, and Talinum teretifolium are all common.

HARVEY[2]) has traced a similar succession of plant species on the prairies of southeastern South Dakota.

The prevernal aspect is due to the flowering of Antennaria campestris, Carex pennsylvanica, Peucedanum nudicaule, Pulsatilla hirsutissima, as principal species, together with Astragalus crassicarpus, Peucedanum foeniculaceum, Draba micrantha, and Ranunculus ovalis without these plants contributing to the formation of a facies. The vernal aspect begins with the blossoming of Troximon (Nothocalais) cuspidatum and Lithospermum angustifolium (= L. linearifolium), closely followed by Castilleja sessiliflora, Lithospermnm canescens, Viola pedatifida and Oxalis violacea, Pentstemon gracilis, Gaura coccinea, Psoralea esculenta, the last two ending the vernal period about the first of Jnne.

The estival aspect is marked by decided climatic changes and flowering of Panicum Scribnerianum, Koeleria cristata, Rosa arkansana, Erigeron ramosus, Delphinium carolinianum (= D. azureum) and Brauneria pallida. The facies is formed by Koeleria cristata, Poa pratensis.

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1) POUND, ROSCOE and CLEMENTS, FREDERIC, E.: The Phytogeography of Nebraska 1900: 348 et seq.; also THORNBER, JOHN, J.: The prairie-grass Formation in Region I. Botanical Survey of Nebraska V (1901); 29—143.

2) HARVEY, Botanical Gazette XLVI: 277—298, Oct. 1908.

Scarcely have these forms flowered before the third week of June when there appear Anemone cylindrica, Physalis heterophylla, Verbena stricta, Linum sulcatum, Allionia littoralis, Festuca octoflora and Aristida purpurea.

The serotinal aspect, perhaps the most distinct of the aspects, is introduced in early July by the general flowering of Agropyron occidentale (= A. Smithii), Buchloë (Bulbilis) dactyloides, Petalostemon (Kuhnistera) purpurea and K. (P.) candida.

The facies is composed of Bouteloua oligostachya, B. hirsuta, B. curtipendula (= racemosa), Buchloë dactyloides with such primary species as Petalostemon purpurea, Verbena stricta, Symphoricarpus occidentalis, Amorpha canescens. — The autumnal aspect begins in early August by the blooming of Helianthus scaberrimus, Solidago rigida, the bunch grasses Andropogon furcatus and A. scoparius. It exends into early October. Its floral activity is terminated, however, by the middle of September by the anthesis of Gentiana puberula and Solidago rigidiuscula.

*Buffalo Grass Formation.* Buffalo grass *Buchloë* (*Bulbilis*) *dactyloides*[1]) and grama grass *Bouteloua oligostachya* are the sole facies. The dense mats of the former are peculiarly exclusive. Other grasses are never abundant, and are to be found only in the intervals between the mats of the buffalo-grass. *Bouteloua curtipendula* and *B. oligostachya* are the most common, while *Aristida purpurea*, *Agropyron pseudorepens*, *Distichlis spicata* var. *stricta* and *Koeleria cristata* are the remaining grasses. *Asclepias pumila*, *Verbena bipinnatifida* are characteristic while *Amorpha canescens*, *Petalostemon candidus*, *Solidago missouriensis* are common and *Yucca angustifolia* (= *Y. glauca*), *Ipomoea leptophylla*, *Psoralea esculenta*, *Dalea aurea* are infrequent.

The area of *Buchloë* is large, but greatly interrupted. The Llano Estacado (Staked Plain) of Texas, a tableland about 4000 feet above sea level, is covered with a buffalo-grass sod. Under different names it is continued north to the Black Hills of Dakota as a treeless plain, in many parts not even a native cottonwood (*Populus monilifera*) being found along the streams for hundreds of miles. This is the true "Great American Desert" of early writers.

That covered by *Bouteloua oligostachya* and *Andropogon scoparius* is more extensive. The fullest development of this formation is in the Dakotas and eastern Montana from which it extends southward through Nebraska and Kansas. The prairie, or range, as it is called in western South Dakota, is tenanted by such characteristic species as: *Stipa comata*, *Bouteloua hirsuta*, *B. oligostachya*, *B. curtipendula* (= *B. racemosa*), *Agropyron glaucum*, *A. repens*, *Yucca*, *Sophora sericea*, *Schrankia*, *Psoralea*, *Astragalus crassicarpus* (= *A. caryocarpus*), *A. flexuosus*, *Gutierrezia*, *Solidago missouriensis*, *S. canadensis*, *S. serotina*, *Helianthus petiolaris*[2]). The Buchloë-prairie type exists on the argillaceous tablelands, the Bouteloua type is found over sandy stretches, thus offering a transition to the sand-hill flora.

The southern extension of the North American prairies is to be found in Texas which has a climate that may appropriately be called "a grass plains climate", and the grasses may be said to form the foundation element

1) SCHAFFNER, JOHN H.: The Spreading of Buffallo Grass. The Botanical Gazette XXVII: 393.

2) WILLIAMS, T. A.: Notes on the Flora of western South Dakota. American Naturalist, XXVI (1892): 256.

of the vegetation. Even in the region of greatest rainfall, however, the climatic conditions, together with geologic and physiographic conditions, result in a decidedly xerophytic vegetation. The grass vegetation is a direct expression of the xerophytic conditions, and certain ecologic types of grasses are found through the entire region, as *Buchloë dactyloides* specifically designated as "buffalo grass". Setting aside the coastal prairies[1]) which are sod prairies with grasses and sedges of mesophytic requirements and annuals similarly adapted to wet, low, coast lands, the prairie plains demand our attention as the southern extension of the prairie region proper.

The prairie plains embrace the grass country of central and north Texas. They merge with the prairies in the wooded country to the east and with the Great Plains proper (Llano Estacado, Edwards Plateau and Stockton Plateau) on the west. The dominant vegetation is a grass formation, but upon the areas of sand and gravel exposed an the hills, bluffs and streamways, where the sod is not compact, timber formations prevail. Grand Prairie which occupies a lower Cretaceous area supports a grass vegetation, accompanied by a very abundant assortment of prairie annuals and herbaceous perennials, with lignescent, tuberous, or bulbous underground parts. The underground parts according to BRAY are several types, as succulent fibrous roots with a thick zone of mucilaginous or saponaceous tissue *(Krameria secundiflora, Yucca rupicola)*; woody subterranean tuberous caudex *Liatris pycnostachya;* mucilaginous bulbs with impervious coats (*Allium*, *Cooperia*), and deep irregular or fusiform roots with hard sclerenchymatous coat (*Aslepias decumbens*). The plants with these characters assist in giving individuality to the grass formation. The Red Beds plain[2]) of reddish chocolate soil, west of the Grand Prairie, shows two specific formations constantly to be distinguished, viz: the *Hilaria Jamesii* association and the *Aristida fasciculata* association which occurs on ridges alternating with the lower areas of *Hilaria*.

These grasses together with the black grama (Hilaria mutica), curly mesquite grass (H. cenchroides) from a fairly close sod in which grow such annuals as Sphaeralcea angustifolia, S. cuspidata, Malvastrum coccineum, Gaillardia pinnatifida, Actinella (Tetraneuris) linearifolia, Perezia runcinata, Xanthium texana, Berlandiera lyrata, Polypteris Hookeriana, Hoffmanseggia stricta and Mentzelia nuda.

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1) See discussion under head of coastal plain forests where these prairies are referred to. The great plains elements extend southward in great strength over the Llano Estacado, the plateau country about Fort Davis, Alpine, Marfa, &c. and are strong over the central Red Beds country, the Grand and Black prairies, and extend in some strength over the black prairie lands to the Gulf at Port Lavaca and Corpus Christi. There is further an element which is not typically Great Plains, or at anyrate is a more mesophytic expression of it which occupies the prairie region in Indian Territory and eastern Kansas and is very strong in the Black and Grand Prairies of Texas. Quoted from a letter, dated Oct. 28, 1903 from Prof. WILLIAM L. BRAY, University of Texas.

2) BRAY, WILLIAM L.: The ecological Relations of the Vegetation of western Texas. Botanical Gazette XXXII; 199, Aug., Sept., Oct. 1901.

The southern part of the Texan prairies receives species from the south and southwest. At the north the prairie annual flora of Oklahoma and Kansas appears to be largely predominant. These prairie annuals form an important factor in the flora especially in the early spring, when there is a solid mass. This disappears before the climax of the grass vegetation season. — West of the Pecos River there is a vast prairie region traversed by many ranges of hills and bluffs and cut up by many arroyos and ravines much of it, however, is simply undulating or nearly level.

The gramineous vegetation of this prairie consists chiefly of the following species: Buchloë (Bulbilis) dactyloides (east of the Pecos), *Bouteloua oligostachya*, B. hirsuta, B. eriopoda B. curtipendula (= B. racemosa), Pappophorum Wrightii, Triodia (Tricuspis) pulchella, Hilaria mutica (north), H. cenchroides (south), Aristida purpurea, A. dispersa (= A. fasciculata), A stricta, A. Schiediana, Muhlenbergia texana, M. arenicola, Andropogon saccharoides, A. scoparius, Lycurus phleoides, Panicum obtusum, P. leucophoeum (= P. insulare), P. Hallii, Setaria caudata.

This prairie although apparently level, is seldom entirely free from shrubs, such as: Clematis Drummondii, Acacia filicina (= A. Hartwegi), Microrhamnus ericoides, Zizyphus obtusifolius Ephedra trifurca, E. antisyphilitica, Larrea mexicana (= Covillea tridentata), Yucca angustifolia (= Y. glauca), Nolina texana, Opuntia arborescens. — The summer display of herbs is owing to the presence of: Talinum aurantiacum, Calophanes linearis, Linum Berlandieri, L. rigidum *Callirhoë* pedata, C. digitata, Sida physocalyx (= S. hastata), S. diffusa, Sphaeralcea hastulata Nyctaginea capitata, Abronia turbinata, Oxybaphus (Allionia) angustifolius, Cooperia Drummondii *Phaseolus retusus*, *Rhynchosia texana*, *Petalostemon candidus*, P. *multiflorus*, Verbena bipinnatifida Chamaesaracha coronopus, Solanum elaeagnifolium, Tradescantia virginica, Commelina virginica C. dianthifolia, Salvia lanceolata, Tetraclea Coulteri, Eriogonum annuum, Croton corymbulosus Asclepias Jamesii (= A. latifolia), Senecio longilobus, Gaillardia pulchella, Riddellia tagetina Gutierrezia eriocarpa, Lygodesmia aphylla, Aster tanacetifolius, Thelesperma gracile.

A large portion of southeastern Texas included between the coast the Rio Grande and the Nueces River is a dry grassy country [1]) and therefore should be included with the prairies. Zones of chaparral and small timber traverse and break this prairie into detached portions. Such trees as *Celtis mississippiensis*, *Prosopis juliflora*, *Fraxinus viridis*, *Acacia Farnesiana*, *Ulmus americana* fringe the dry forks and beds of streams. One of the prairies is covered with *Elionurus ciliatus*, *Aristida purpurea*, *Sporobolus cryptandrus*, while near the Rio Grande and coast grow *Bouteloua texana*, *Cynodon dactylon*, and *Bouteloua oligostachya* is rarely seen.

The Grand and Black prairies, lying parallel, with only the narrow strip of lower Cross Timbers between, extend from near Austin north in a broad strip to the Red River bottoms, forming an extensive area over which trees and forest species are mainly restricted to narrow stream bottoms. Here and there island strips of grassy prairie are found in the timbered region farther east becoming smaller and smaller. The timber is restricted to narrow strips in the river bottoms in the territory of the coast prairie which extends from

1) HAVARD, V.: Report on Flora of western and southern Texas. Proceedings U. S. National Museum, 1885: 482—485; also consult COOK, C. F.: Change of Vegetation of the south Texas Prairies. Circular 14. U. S. Bureau of Plant Industry.

western Louisiana to San Antonio Bay and irregularly beyond. These prairies are characterized by a rich growth of grass and many flowering plants and spreading trees of *Quercus virens* (= *Q. virginiana*) drooped with *Tillandsia usneoides* border the grassland [1]).

According to BRAY [2]) the pronounced xerophytic aspects of this grassland vegetation are due to the occurrence of summer drouths indicated by the occurrence of perennial roots storage tubers, bulbs etc. The associates of the grasses are so numerous that for some weeks during spring, these flowering plants may quite overshadow the grasses so that the prairiers are brilliant with color.

The following prairie annuals occur in great abundance: Draba cuneifolia, Astragalus Nuttallianus, A. Lindheimeri, Lupinus texensis, Euphorbia bicolor, Croton corymbulosus, C. texensis, Gaura suffulta, Monandra citriodora, Centaurea americana, Evax prolifera, Gaillardia pulchella, Gutierrezia texana, Hymenopappus corymbosus, Parthenium hysterophorus. The perennials with roots and tubers of various structural adaptations are Yucca rupicola, Krameria secundiflora, Astragalus caryocarpus, A. mexicanus, Indigofera leptosepala, Psoralea esculenta, Stillingia sylvatica, Oenothera (Hartmannia) speciosa, Asclepiodora decumbens, Salvia farinacea, S. azurea, Pentstemon cobaea, Cucurbita foetidissima, Lygodesmia aphylla together with such bulb plants as Allium Nuttallii, Nothoscordum striatum (= N. bivalve), Androstephium violaceum, Zephyranthes texana, Cooperia Drummondii, C. pedunculata.

*Loess Mound Formation.* The loess mounds on which a peculiar flora grows parallel the Missouri River in Missouri and Iowa. There is a heavy belt of timber back of the mounds and back of this is a high rolling prairie. Between the mounds and the river is a fertile gumbo bottom-prairie.

Where the south and west side are steep and precipitous there are found such plants as Yucca angustifolia, Gaura coccinea, Psoralea argophylla, Sporobolus airoides; where they descend gradually to the bottom are Pentstemon grandiflorus, Astragalus lotiflorus, Dalea enneandra (= Dalea taxiflora), while on the north are pockets running up the sides of the mounds covered with dwarfed trees and shrubs: Corylus virginiana, Rhus glabra, Salix humilis. The tops of the mounds present a denuded appearance and of considerable elevation and upon them grow Castilleia sessiliflora, Psoralea argophylla, Gaura coccinea, Glycyrrhiza lepidota, Yucca angustifolia, Sporobolus airoides, Anemone cylindrica, Liatris punctata, Bouteloua hirsuta, Dalea enneandra, Lithospermum angustifolium (= L. linearifolium), Lygodesmia juncea, Lactuca pulchella and Onosmodium molle [3]).

## b) The Sand Hill Territory.

The sand hills extend from Nebraska into the Dakotas on the north Kansas, Oklahoma, Indian Territory and Texas on the south and into northeastern Colorado. Some sand hill species enter the level prairies: *Aristida basiramea*, *A. oligantha*, *Carex stenophylla*, *C. stipata*, *Cyperus*

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1) BAILEY, VERNON: Biological Survey of Texas. North American Fauna No. 25 U.S. Biological Survey 1905, 19.

2) Distribution and Adaptation of the Vegetation of Texas. Bulletin University of Texas No. 82 Scientific Series No. 10 1906: 86.

3) BUSH, B. F.: Notes on the mound Flora of Atchison County, Missouri. 6th Report Mo. Botanic Garden. 121.

*Schweinitzii*, *Gaertneria* (*Franseria*) *tomentosa*, *Hypericum majus*, *Polygonum camporum*. The trees are almost entirely confined to the narrow belts which border the streams. These belts are wider in the east, but in the west they are contracted and the trees become shrub-like. They are *Pinus scopulorum*, *Juniperus virginiana*, *J. scopulorum*, *Ulmus americana*, *Celtis occidentalis*, *Fraxinus viridis*, *Negundo*, *Quercus macrocarpa*, *Salix humilis* and *tristis*, *Rhus glabra* and *trilobata* [1]) etc.

The most abundant woody plant of the sand hills is *Amorpha canescens*. Next comes the western sand cherry *Prunus Besseyi*, *Ceanothus ovatus*. All these belong to the true sand hill flora. The sand hill region is the region of the bunchgrass (blue-stem and beard-grass), blow-out and sand-draw formations.

The facies of the blue-stem formation are Andropogon scoparius, Stipa comata, Calamagrostis (Calamovilfa), and Andropogon Hallii. The secondary species are Eragrostis tenuis (= E. trichodes), Oryzopsis (Eriocoma) cuspidata, Muhlenbergia pungens, Bouteloua hirsuta, B. oligostachya, Sporobolus cryptandrus, Cyperus Schweinitzii. Modifications are imparted to it by Prunus Besseyi, Rosa arkansana, Amorpha canescens, Ceanothus ovatus and Yucca angustifolia (= Y. glauca), while as additional species occuring here should be mentioned Cycloloma atriplicifolium, Froelichia floridana, Eriogonum annuum, Chrysopsis villosa, Aplopappus (Eriocarpum) spinulosum, Opuntia humifusa (= mesacantha), Psoralea lanceolata. The facies of the beard-grass formation are Aristida purpurea, Aristida basiramea, Sporobolus cuspidatus and Stipa spartea. Secondary species of grasses are Panicum Scribnerianum, Aristida oligantha, Koeleria cristata, and Eatonia obtusata while Helianthus petiolaris, Potentilla arguta, Argemone alba, Plantago Purshii and Linum rigidum also occur.

Blow-out Formation (see ante, Transition district § 2, p. 525). The blow-out formation is restricted to peculiar crateriform hollows formed by wind action, and termed blow-outs. It occurs of course only in the sand hills proper, since it is here only that blow-outs are found. The facies are Redfieldia flexuosa, Muhlenbergia pungens, Eragrostis tenuis (= E. trichodes), Oryzopsis cuspidata and Calamagrostis (Calamovilfa) longifolia, with secondary species, such as Tradescantia virginica, Eriogonum annuum, Oenothera serrulata, Lathyrus ornatus var. flavescens, Astragalus (Phaca) longifolia and Euphorbia petaloides.

Sand-Draw Formation. The sand-draw formation has much in common with the blow-out formation. It is less frequent and grasses are not controlling. Their place is taken by Cristatella Jamesii and Polanisia trachysperma while the grasses if present are represented by scattered tufts of Munroa squarrosa, Eragrostis major and Paspalum setaceum associated with Euphorbia petaloides, E. hexagona and E. montana. According to RYDBERG [2]) in the sand-draws grow Ipomoea leptophylla, Argemone platyceras, Mentzelia nuda, Oenothera albicaulis, Lupinus argenteus var. procumbens, Cleome serrulata (= C. integrifolia), Chrysopsis villosa, Asclepias speciosa, Croton texensis, Eriogonum annuum, E. corymbosum, Prunus pumila while rarer plants are Pectis angustifolia, Acerates auriculata, Petalostemon tenuifolium, P. gracile.

All along the principal river valleys of Kansas especially over the broad valley of the Arkansas river are hills of sand with such plants as Prunus chicasa (= P. angustifolia), Lithospermum hirtum (= L. Gmelini), Yucca angustifolia (= Y. glauca), Discopleura capillacea, Viola tricolor var. arvensis, Cristatella Jamesii, Linaria canadensis, Froelichia gracilis, Hosackia Purshiana

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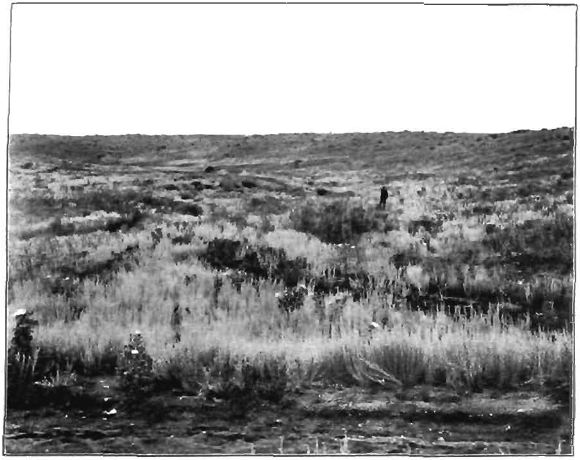
1) BESSEY, CHARLES E.: Some agricultural Possibilities of western Nebraska. Annual Report Nebraska State Board of Agriculture 1900: 75—116; also HITCHCOCK, A. S.: loc. cit.

2) RYDBERG, P. A.: The Flora of the high Nebraska Plains. American Naturalist XXV: 485 May 1891; Flora of the Sand Hills of Nebraska, Contributions U. S. National Herbarium (1895) III: 133—203



Association of **Artemisia frigida** Willd.

Growing in the mesa region together with Argemone intermedia Sweet in the left foreground, Stipa Vaseyi Scribn. the tall grass in the center and in the background Yucca angustifolia Pursh (= Y. glauca Nutt).

*Photograph by Dr. H. L. Shantz.*

**Euphorbia marginata** Pursh.

Growing on the outer margin of salt marshes in the prairie district.

Photograph by Dr. H. L. Shantz.

(= Lotus americanus), Pentstemon acuminatus, Pyrrhopappus scaposus, Cyperus acuminatus, Flaveria angustifolia [1]).

## C. Foothill District.

The foot-hill district extends northward through the Dakotas, Montana, Assiniboia and Alberta to its northern limit in Athabasca. On the south it extends along the mountains into Colorado and New Mexico. Physiographically it is a region of high, barren table-lands, broken by numerous canyons and dotted with frequent buttes. Floristically it is marked by the great number of mountain plants which here find their distributional boundary on the east [2]). One territory the Pine Ridge, is akin topographically and phytogeographically to the Black Hills of South Dakota. In another territory the flora of the foothills represent an eastward extension of the flora of the Rocky Mountains. The trees of the foot-hills are not confined to the canyons as in the sand-hills but on the contrary grow on the hills and knobs of the mountains. They are *Pinus ponderosa* var. *scopulorum*, *Juniperus scopulorum*, *J. virginiana*, *Populus monilifera* (= *P. deltoides*), *P. angustifolia*, *Ulmus americana*, *Celtis occidentalis*, *Fraxinus viridis* (= *F. lanceolata*), *Fraxinus pennsylvanica*, *Prunus americana*, *Acer glabrum*, *Negundo aceroides*, *Ostrya virginiana*, *Betula occidentalis* and a rich assortment of shrubs [3]). Three plant formations may be distinguished, (1) the undershrub formation of table lands and bad lands, (2) the mat and rosette formation of buttes and hills, (3) the grass formation of high drairies and sandy plains.

### 1. Undershrub Formations.

The undershrub formation is not peculiar to the foothills of the prairie province; it here covers but a small area in comparison with vast stretches occupied by it in the Great Basin. In the foothills, this formation exhibits two types, the one confined to high, somewhat grassy table lands, the other found solely on alkaline or bad lands. The former may be termed the sage-brush type, the latter the greasewood-white-sage type [4]).

*Sage Formation.* (See plate XII of *Artemisia frigida*). This is named the sage-brush formation, because the westward species of *Artemisia*, chiefly *A. tridentata*, constitute the bulk of its controlling elements. In Nebraska *A. tridentata*, *A. frigida*, *A. filifolia*, *A. cana* and *A. canadensis* are found on the high plains and barren table-lands of the foot-hill region. *Bigelovia graveolens* (= *Chrysothamnus nauseosus*), *Eurotia lanata*, *Gutierrezia euthamiae*

1) CARLETON, M. A.: Characteristic sandhill Flora. Transactions Kansas Academy Science XII part I; 32—34.

2) POUND, ROSCOE and CLEMENTS, F.: The Phyto-Geography of Nebraska. 83.

3) BESSEY, CHARLES, E.: Annual Report Nebraska State Board of Agriculture 1900: 98—101; DARTON, D. H.: Pine Ridge Timber. 19th Report U. S. Geological Survey. 1897—98; Part. V.: 387; RAMALEY, FRANCIS: Wild Flowers and Trees of Colorado. 78 pages, 1909.

4) POUND, ROSCOE and CLEMENTS, F. E.: The Vegetation Region of the prairie Province. Botanical Gazette XXV: 393.

(= *G. sarothrae*), singly or collectively constitute the principal facies in the middle prairie region. The secondary species are few and unimportant. The undershrubs are sparsely disposed and with these a few isolated mats of *Bouteloua* and occasional stragglers of *Pectis* are about all that are to be found. However, a very pronounced formation of the sage-brush kind takes exclusive possession of extensive sandy areas in the table-lands of the foot-hill region. *Artemisia filifolia* (see Fig. 27 page 523) constitutes the sole facies. It grows in dark green bunches, 3—5 centimeters wide and very high. These bunches stand less than a meter apart and at the edges of the formation by several meters. These areas are readily discernable at a considerable distance. *Artemisia frigida* is frequently a secondary species. *Carex stenophylla* is the characteristic turf-builder of this formation, while *Stipa comata*, *Bouteloua oligostachya*, *Calamagrostis* (*Calamovilfa*) *longifolia*, although present, are of little importance. Some species have been derived from the eastern sand-hills: *Psoralea lanceolata*, *Chrysopsis villosa*, *Helianthus petiolaris* and *Lathyrus polymorphus* (= *L. decaphyllus*).

*Greasewood-white-sage Formation.* The loose and easily eroded soil of the Bad Lands due to the washing away of canyon sides and buttes together with the heat and slight rainfall combine to render the vegetation a meager one. Two undershrubs give name to the formation, viz: the greasewood *Sarcobatus vermiculatus* and the white sage *Eurotia lanata*.

Some secondary species that take part in the formations are found in the edges of the Bad Lands. Stephanomeria minor (= Ptiloria tenuifolia) is a secondary species. In barren gulches Astragalus multiflorus and in dry canyons Cryptanthe Fendleri occur. The sand binding grass Calamagrostis (Calamovilfa) longifolia is in the Bad Lands of Nebraska. In the Dakotas, bunch-grasses, Oryzopsis (Eriocoma) cuspidata, Andropogon scoparius are reported as well. Cnicus (Carduus) undulatus, Aster multiflorus, Gutierrezia euthamiae (= G. sarothrae), Bigelovia graveolens (= Chrysothamnus nauseosus), Musenion tenuifolium, Mentzelia ornata (= M. decapetala), Oenothera caespitosa, Lesquerella Ludoviciana (= L. argentea) and Eriogonum Jamesii have been observed usually along the edges. This list shows how barren and sterile such a territory is.

*Cercocarpus Scrub Formation.* This scrub formation, according to RAMALEY[1]) exists in north central Colorado where the *Cercocarpus* bushes grow three feet tall and are, as a rule, so closely associated that it is difficult to walk between them. Sparsely distributed over the landscape, the botanist sees trees of *Pinus ponderosa* var. *scopulorum* and *Juniperus* (*Sabina*) *scopulorum*. On limestone ledges the shrubs are often distantly placed.

The plants of this formation[1]) are Townsendia grandiflora, Erysimum asperrimum, Actinella (Tetraneuria) acaulis, A. planata, Astragalus succulentus, A. crassicarpus, Harbouria (Cicuta) trachypleura, Mammillaria missouriensis, Opuntia polyacantha, Lesquerella (Vesicaria) montana, Lithospermum angustifolium (= linearifolium), Phlox bryoides, Eriogonum flavum (E. crassifolium), Frasera speciosa, Leucocrinum montanum, Astragalus Drummondii, A. caespitosus, Oxytropis multiceps, Pentstemon secundiflorus (= P. unilateralis), Mertensia brachyloba. The following plants are occasionally found: Yucca angustifolia (= Y. glauca), Helianthus petiolaris and Arenaria Hookeri.

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1) University of Colorado Studies V: 119—131.

## 2. Mat Rosette Formations of Buttes, Cliffs and Hills.

This is the chief of the foot-hill formations in Nebraska. Almost the sole vegetation is sparse and of the mat or rosette type on buttes, cliffs on rocky hills, rocky ridges and on sandy hillsides. At times a considerable number of secondary species occupying the intervals between the mat-forming species. The monotony found in the bunch-grass formations is relieved in this formation by the bright and showy flowers. Two types may be distinguished (a) the mat formation of buttes and cliffs, including also the mat formation of rocky ridges and stony hills and (b) the rosette formation of sandy hillsides.

*Mat Formation of Buttes and Cliffs.* This varies considerably in respect to the constituent species.

Thus on Scott's Bluff according to POUND and CLEMENTS are found Arenaria Hookeri, Gilia spicata, Phacelia circinata (= P. heterophylla), Astragalus caespitosus, Eriocarpum grindelioides (= Aplopappus Nuttallii), Aplopappus (Stenotus) armerioides, Picradenia acaulis, Eriogonum cernuum, Townsendia sericea (= T. exscapa) while Arenaria Hookeri, Gilia pungens var. caespitosa, G. iberidifolia, Phlox Hoodii, Eriogonum flavum, E. multiceps, E. cernuum, Musineon tenuifolium, Astragalus (Orophaca) sericeus, Homolobus caespitosus and H. montanus (= Astragalus kentrophytus) are characteristic on the cliffs and foothills of the Lodge Pole territory of Nebraska. The chalk rocks of this territory support Gilia iberidifolia, G. congesta and Phlox Hoodii and Oreocarya fulvocanescens is a cliff inhabitant. The buttes of the Hat Creek basin show Eriogonum flavum, Sedum stenopetalum, and Eriocarpum grindelioides (= Aplopappus Nuttallii), Berberis repens (= B. aquifolium) and Symphoricarpos pauciflorus are to be met with on the buttes or upper canyon sides in this basin. The secondary species are emigrants from other xerophytic localities.

In the Lodge Pole territory the dominant and characteristic plants of rocky ridges and high, stony hillsides are Phlox bryoides, P. Hoodii, Arenaria Hookeri, Eriogonum flavum, Lesquerella alpina, Townsendia exscapa and Viola Nuttallii. Cheilanthes lanuginosa grows on the exposed rocks. — *Forming dense cespitose masses on high rocky situations in the Pine Ridge* country are Homalobus caespitosus, Gilia pumila, Arenaria Hookeri, Eriogonum flavum, Loeflingia texana and here and there are Euphorbia montana, Opuntia humifusa, O. missouriensis (= O. polyacantha) and Thermopsis rhombifolia. Cercocarpus parvifolius is an undershrub of such situations.

*Rosette Formation of Sandy Hillsides.* The hills over which it prevails are not unlike the true sandhills being almost pure sand and very sparsely covered with vegetation, but they have no blow-outs and the bunch-grasses are absent. Rosette plants are prominent.

Hill after hill will be covered sparingly with Polygala alba, Pentstemon albidus, P. caeruleus (= P. angustifolius), Phlox Douglasii, Paronychia Jamesii, Astragalus sericeus and Oreocarya suffruticosa (= Krynitzkia Jamesii), Polygala alba and Paronychia Jamesii are the most important and abundant of these plants. Few grasses enter this formation. The most frequent are small circular mats of Bouteloua oligostachya or even Buchloë dactyloides and a few individuals of Stipa comata with Rumex venosus. Astragalus sericeus is almost buried in the sand. Elsewhere Gilia spicata, Oenothera caespitosa, Arenaria Hookeri, Paronychia Jamesii, Pentstemon glaber take part in the rosette formation.

*Sandstone Bluff Formation.* This formation of several associations is found along the bluffs which border the deep narrow valleys of the streams in the

prairie district. In Iowa in Winneshiek County[1]) the following associations are found on the St. Peter sandstone.

Upon the harder exposed rock surfaces grow the following lichens and mosses:

| | | |
|---|---|---|
| Lecanora rubina Vill. | Urceolaria scruposa L. | Bryum intermedium Brid. |
| Physcia caesia Hoffm. | Placodium aurantiacum Light. | Ceratodon purpureus Brid. |
| Parmelia conspersa Ehrh. | Buellia spuria Schaer. | Dicranella heteromalla Schimp. |

Upon the upper portion of the ledges in crevices, or on exposed surfaces where a little sandy soil had accumulated:

| | | |
|---|---|---|
| Cladonia cornucopioides L. | Sisyrinchium angustifolium Mill. | Potentilla tridentata Sol. |
| Cladonia rangiferina L. | Polygala viridescens L. (= P. sanguinea L.) | Prunus pumila L. |
| Grimaldia barbifrons Bisch. | Linum sulcatum Rid. | Pirus melanocarpa Willd. (= Aronia nigra Willd.) |
| Polytrichum piliferum Schreb. | | Scutellaria parvula Michx. |
| Selaginella rupestris L. | | |

Where the sandy soil on the rock ledges is greater the following occur:

| | | |
|---|---|---|
| Muhlenbergia glomerata Trin. (= M. racemosa Michx.) | Lespedeza capitata Michx. | Gnaphalium obtusifolium L. (= G. polycephalum Michx.) |
| Aristida basiramea Engelm. | Amorpha canescens Pursh. | Solidago tenuifolia Pursh. (= Euthamia caroliniana L.) |
| Bouteloua hirsuta Lag. | Helianthemum canadense L. | Solidago rigidiuscula T. & G. |
| Eragrostis Frankii Steud. | Lechea tenuifolia Michx. | Aster sericeus Vent. |
| Amelanchier alnifolia Nutt. | Polygonum camporum Meissn. | |

In the better shaded, or protected places, the botanist finds Woodsia ilvensis, Rubus Baileyanus (= R. Enslenii), while the sandy talus below the ledges yields Sporobolus brevifolius, Cyperus filiculmis, Polygonum tenue, P. Douglasii, Solidago nemoralis, Lechea tenuifolia, Helianthemum canadense. — The deeper soil of the talus and the sandy ledges encourages a tree vegetation: Betula papyrifera, Quercus macrocarpa, Q. tinctoria, Amelanchier canadensis, A. rotundifolia, Prunus pennsylvanica, P. virginiana and the usual associated mesophytic herbs. Elsewhere on the wetter sandstone grows Marchantia polymorpha, Porella platyphylla, Athyrium filix-foemina, Cystopteris bulbifera.

## 3. The Grass Formations.

*Grass Formation of High Prairies and Level Sandy Plains.* This is emphatically a grass formation and resembles at a distance a typic prairie. It is controlled by two grasses which not only furnish the bulk of the vegetation and give aspect to the landscape, but sometimes take exclusive possession of extensive areas. *Stipa comata* and *Agropyron spicatum* (= *A. divergens*) are the ruling grasses usually associated with one or the other predominant. The high rolling prairies are controlled by *Stipa comata.* The level sandy stretches where the covering is thin and in patches are dominated by *Agropyron pseudorepens.*

The Stipa formation of high prairies is the chief grass formation of the region, where the typic grass forms a sod in which secondary species occur such as *Lupinus plattensis*, *Astragalus mollissimus*, *A. adsurgens*, *Oxytropis*

1) Shimek, B.: The Flora of the St. Peter sandstone in Winneshiek County, Iowa. Bulletin Laboratories Natural History, State University of Iowa. V. No. 4: 225—229.

*Lamberti*, *Psoralea argophylla* and in many places *Tradescantia virginica*, all with blue flowers which display their colors to perfection against the color of the glistening white awns of *Stipa*. *Thelesperma trifidum* with yellow flowers also are found and as of secondary importance *Psoralea digitata*, *P. tenuiflora*, *P. esculenta* also with blue flowers. Later in the summer when *Stipa* becomes dry, *Aster canescens*, *A. commutatus*, *Liatris punctata*, *Oxybaphus* (*Allionia*) *linearis* and *O. hirsuta* appear.

*Bouteloua* (*Grama Grass*) *Formation*. Elsewhere in Kansas on the high prairies are *Bouteloua curtipendula* (= *B. racemosa*), *B. oligostachya*, *B. hirsuta*, *Lepachys tagetes*, *Gaillardia pulchella*, *Engelmannia pinnatifida*, *Erysimum asperum*, *Astragalus lotiflorus* and *mollissimus*, *Ipomoea leptophylla*, *Oenothera Hartwegi* and the prevailing sunflower *Helianthus petiolaris*.

The same formation occupies practically the whole mesa region and the low land surrounding it at the eastern base of Pikes Peak in Colorado. It extends many miles north and south and is also typic of the high plains eastward. *Bouteloua oligostachya* is the dominant species of the formation. The hills and ridges are occupied by *Bouteloua hirsuta*, alternating with *Andropogon scoparius* (see Fig. 27 pag. 523) and *Koeleria cristata* which often become dominant, while the grama grass occupies the sides of slopes and level expanses. Alternating with this are *Andropogon furcatus* and *Calamovilfa longifolia*. It is here that the most important associations of the formation are found, many of which extend for many miles without interruption. *Grindelia squarrosa* forms such an association, while *Schaedonnardus paniculatus* (= *S. texanus*) and *Thelesperma intermedia* unite to form one. The *Gutierrezia sarothrae* association occurs more often near the mountains and *Artemisia canadensis* is also important in similar localities. *Opuntia polyacantha* (= *O. missouriensis*) and *O. arborescens* (see Fig. 28) occur but sparingly. Other associations occur in which such species as *Carex stenophylla*, *Selaginella densa*. *Yucca angustifolia* (= *Y. glauca*) (see Fig. 28), *Plantago Purshii*, *Lupinus argenteus* are prominent.

The principal species of the prevernal aspect, according to SHANTZ[1]) are Leucocrinum montanum, Townsendia sericea (= T. exscapa), Anemone patens (= Pulsatilla hirsutissima), while the secondary species are Cymopterus glomeratus (= C. acaulis), Cymopterus (Phellopterus) montanus. The greatest number of spring flowers are produced on the north slopes, because here the moisture content of the soil is greater, and this aspect is characteristic of the mesa before the spring rains appear. The vernal aspect is ushered in with the spring rains and usually extends from about the first of May to the middle of July. The principal species are Senecio oblanceolatus, Yucca angustifolia (= Y. glauca), (see Fig. 28), Kellermannia yuccogena, Pleospora phragmospora, Astragalus Drummondii, Pentstemon coeruleus (= P. angustifolius), P. secundiflorus, Opuntia missouriensis (= O. polyacantha), Astragalus bisulcatus, Euphorbia robusta, Uromyces scutellatus, Echinocereus viridiflorus, Arenaria Fendleri, Sophora sericea, Ipomoea leptophylla. The aestival aspect is marked by the increase in temperature and decrease in rainfall. Then, according to my observations the mesa is dry and the surface soil looks parched. The facies is due, to Bouteloua oligostachys, B. hirsuta, Andropogon scoparius, A. furcatus, Muhlenbergia gracillima. The principal species are Artemisia frigida, Gutierrezia euthamiae (G. sarothrae), Aristida

1) Botanical Gazette XLII: 16—47, 179—207.

longiseta, Psoralea tenuiflora, Plantago Purshii. In general it may be said, that the mesa top is dominated by the typic Bouteloua oligostachya formation, the crests by B. hirsuta, the low ground with this formation alternating with Muhlenbergia gracillima, or Andropogon occidentale. During the month of August, the rainfall decreases markedly and is only slight in September. The principal autumnal species are Artemisia frigida, Gutierrezia euthamiae (= G. sarothrae), Grindelia squarrosa, Senecio spartioides, Chrysopsis villosa, Bigelovia graveolens var. glabrata (= Chrysothamnus graveolens). The secondary species are Liatris (Lacinaria) punctata, Eriogonum Jamesii, Aster polycephalus, Munroa squarrosa, Artemisia canadensis, Chrysothamnus plattensis, Eurotia lanata. Hence from a study of the composition of this formation it appears that it is typic of the high plains.

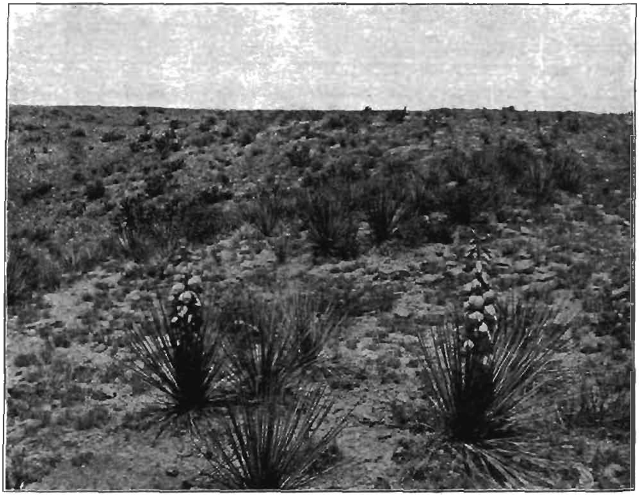

Fig. 28. Yucca augustifolia Pursh (= Y. glauca Nutt.) in the foreground and Opuntia arborescens Engelm. in the background. Photograph by Dr. H. L. SHANTZ with permission of United States Department of Agriculture.

*Agropyron Formation of level, sandy and gumbo Plains.* On low hillsides the sod is more or less thick, but on level stretches it is sparse. The controlling grass of this formation is *Agropyron spicatum* associated with *Festuca tenella* (= *F. octoflora*), *F. ovina*, *Koeleria cristata*, *Elymus elymoides*, *Buchloë dactyloides*, *Bouteloua oligostachys* with large patches of *Monarda citriodora*, *Hedeoma Drummondii*, *Malvastrum coccineum*, *Plantago Purshii* and *Rumex venosus*. On less sandy situations near the hills *Malvastrum coccineum* is almost controlling. *Astragalus microlobus* is often copiously distributed over definite areas sprawling in the *Agropyron* sod.

*Pepper grass-Cactus Formation.* This is included in the grass formations, because the covering mainly consists of *Bouteloua oligostachys* and *Buchloë (Bulbilis) dactyloides*, both present in nearly equal importance. From the middle of June throughout the remainder of the year these grasses dry up and are not conspicuous. Then the pepper-grass *Lepidium intermedium* appears interrupted by patches of *Opuntia missouriensis* (= *O. polyacantha*) [1]. Secondary species have little or no importance in this formation. The pepper-grass cactus formation extends over vast stretches of mesa and table-land north of the Platte River, on the flat tops of peaks and buttes in the Bad Lands of Nebraska and Montana.

## 4. The Salt Marshes and Meadows.

Salty or alkaline marshes or meadows are to be found throughout the prairie region. In the meadows *Distichlis spicata* var. *stricta* is always the controlling and is often the sole inhabitant. *Agropyrum pseudorepens* is often associated with it.

In small, salt water ponds in the bottoms, *Ruppia occidentalis* occurs, while in salty wet soil grows *Salicornia herbacea*, and in the drier soil *Atriplex hastata*, *A. argentea* are found in dense patches. *Polygonum ramosissimum* also occurs in places. In southern Kansas are *Corispermum hyssopifolium*, *Cycloloma platyphylla*, *Atriplex expansa*, *Kochia americana*, *Scirpus maritimus* and *S. Torreyi*, and in Big Salt Marsh in addition, according to Hitchcock, grow *Aster exilis*, *Flaveria angustifolia*, *Chenopodium rubrum*. All through the central part of Kansas [2], salt marshes and salt springs are quite common and small salt licks are found in most parts of the state.

Along a stream issuing from Big Marsh one of the largest of the salt marshes occur Scirpus pungens (= S. americanus), S. campestris, S. lacustris, and in the higher parts of the alluvial deposit Distichlis spicata, Panicum crus-galli, Elymus virginicus, Spartina cynosuroides, Rumex britannicus, Polygonum hydropiper, P. persicaria, P. ramosissimum, Amarantus chlorostachys (= A. hybridus) and Iva ciliata. On the outer margin of the barren salt area are the following circumareas of vegetation:

1. Distichlis spicata L. (= D. maritima Raf.).
2. Distichlis spicata L., Polygonum ramosissimum Michx., Suaeda diffusa Watson.
3. A wide, dry circumarea of spicata L., Polygonum ramosissimum Michx., Suaeda diffusa Watson, Iva ciliata Willd. (rare).
4. Distichlis maritima Raf., Polygonum ramosissimum Michx., Suaeda diffusa Wats., Iva ciliata Willd., Sporobolus heterolepis Gray, S. texanus Vasey, Atriplex expansa Wats. (rare), Aster multiflorus Ait.
5. Iva ciliata Willd., Distichlis spicata L., Polygonum ramosissimum Michx., Sporobolus heterolepis Gray. S. texanus Vasey, Atriplex expansa Wats., Aster multiflorus Ait., Scirpus pungens Vahl, Hordeum jubatum L., Panicum virgatum L., Gaura parviflora Dougl. (occasional), Ambrosia psilostachya DC. (rare).

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1) See also BESSEY, CHARLES, E.: American Naturalist XXXII: 111.

2) SCHAFFNER, JOHN H.: Notes on the salt marsh Plants of northern Kansas. Botanical Gazette XXV (1898): 255—260; HITCHCOCK, A. S.: Ecological plant Geography of Kansas, loc. cit.

6. Ambrosia psilostachya DC. (abundant and gives character to this belt), Distichlis spicata L., Polygonum ramosissimum Michx., Iva ciliata Willd., Sporobolus heterolepis Gray, Hordeum jubatum L., Scirpus pungens Vahl, Panicum virgatum L., Gaura parviflora Dougl., Glycyrrhiza lepidota Nutt.

7. Transition circumarea on the outer margin of the salt marsh. Iva ciliata Willd., Sporobolus heterolepis Gray, Panicum virgatum L., Gaura parviflora Dougl., Ambrosia psilostachya DC., Glycyrrhiza lepidota Nutt., Aster multiflorus Ait, Helianthus annuus L., Erigeron (Leptilon) canadensis L., Xanthium strumarium L., Grindelia squarrosa Pursh, Desmanthus brachylobus Benth. (= Acuan illinoënsis Michx.), Amorpha fruticosa L., Oenothera biennis L., Physalis lanceolata Michx.. Euphorbia glyptosperma Engelm., E. marginata Pursh., (see plate XII), Amaranthus blitoides Wats., Elymus virginicus L., Spartina cynosuroides L., Scirpus pungens Vahl.

## 5. Fresh Water Plants and Wet Meadow Formations.

*Marsh Formation.* The four types of this formation are constant only when each is subject to certain typic conditions. In other words they exhibit numerous gradations through the suppression of proper facies or the intrusion of other facies. Certain species of general distribution are of course, common in marshes everywhere. Thus *Eleocharis palustris* is found in the four types of marsh, while *Ranunculus (Oxygraphis) Cymbalaria* is lacking only in the false loose-strife association.

Reed-grass Rush Association. This type of marsh is found in the lowlands along rivers an on the flood lands of the principal streams in the prairie district. The facies are *Phragmites communis*, *Scirpus lacustris*, *S. fluviatilis*, *Typha latifolia*, *Alisma plantago* and *Sagittaria variabilis* while *Sparganium eurycarpum*, a common element may occasionally assume the importance of a facies. Sometimes the individual facies become isolated and these are represented in marshy places by one or two facies, sometimes *Scirpus lacustris* or *Typha* alone, sometimes *Typha* and *Sparganium*, or *Sagittaria* and *Sparganium*.

The most typic of these marshes, as closed formations in which layers are developed, occur along the Missouri River. The primary layer is composed invariably of either Phragmites communis, or Scirpus fluviatilis, or both. The secondary layer is constituted by Phalaris arundinacea and species of Scirpus, viz: S. lacustris, S. atrovirens, S. pungens (= S. americanus). Between the clumps formed by Scirpus, Sagittaria, Alisma, Typha and Sparganium grow. Carex lurida occupies the muddy edges; Calamagrostis canadensis in the shallow pools; Eleocharis palustris a dense carpet from the shore throughout the swamps; broken by yellow patches of Ranunculus multifidus (= R. delphinifolius), Ranunculus cymbalaria and occasionally by Ranunculus pennsylvanicus. Herpestis (Monniera) rotundifolia is a common floating plant while Cicuta maculata and Lytbrum alatum are found to a limited extent along the Niobrara River.

Water hemlock Association. This type is found in the sub-sand hills under the sandhills proper. The facies are water hemlock *Cicuta maculata*, *Asclepias incarnata*, *Lythrum alatum*, and *Scirpus atrovirens*. — Smartweed Association. This is of wide distribution, occuring in wet ravines and canyons. It is never of large extent. The facies are *Polygonum lapathifolium*, *P. incarnatum*, *P. acre* (= *P. punctatum*) and these are not in layers. — False loosestrife Association. This occupies broad shallow ditches which are

often filled with a dense growth of *Ludwigia polycarpa*, *Ammannia coccinea* and *Penthorum sedoides* while *Eleocharis palustris* forms thick carpets at the edges, associated occasionally with *Nasturtium palustre*, *Mentha canadensis; Spirodela polyrhiza* floats on the surface of the water.

*Wet Meadow Formation.* This type of formation occurs more especially in the sand-hills and foothills, but occasionally in the prairies proper. — Rush Meadow Association: This type of wet meadow is frequent in the sub-sand-hills. The facies are *Juncus tenuis*, *J. nodosus*, *Scirpus atrovirens* and *S. pungens* (= *S. americanus*). *Juncus tenuis* and *Scirpus atrovirens* are most commonly associated and with them *Glyceria nervata*. In more sandy meadows to the westward *Juncus nodosus* and *J. Torreyi* are prevailing. — Fern Meadow Association: These meadows are confined to wet valleys and canyons of the Loup and Niobrara and the valleys of the principal prairie rivers. They consist of almost exclusively two facies *Nephrodium* (*Aspidium*) *thelypteris* and *Onoclea sensibilis* with which ferns are associated *Epilobium lineare*, *Hypericum majus*, *Galium trifidum* and *Campanula aparinoides*. — Sedge Meadow Association: This association is of rare occurence in Nebraska and then along the Missouri River and main streams. *Carex stricta*, *C. filiformis* var. *lanuginosa*, *Spartina cynosuroides* occur in such formations.

*Pond and Stream Formation.* This exists in several well characterized types mentioned below viz.:

Pondweed Association: This is the most widely distributed aquatic association of the prairie region. The facies are *Potamogeton natans*, *P. amplifolius*, *P. pauciflorus* (= *P. foliosus*), *Myriophyllum spicatum*, *Zannichellia palustris* and *Ceratophyllum demersum*, while *Potamogeton spirillus*, *P. hybridus* (= *P. diversifolius*), *P. zosteraefolius* occuring as secondary species are rare. — Pond-lily Association: The ponds where aquatics grow are of two kinds; those in which the facies is *Nuphar advena*, and those in which *Nymphaea tuberosa* and *Nelumbo lutea* are found. The former type is found in small ponds in the sand-hills and especially in the sub-sand-hills. The second type occurs in the edge of the wooded bluff country. Here the association of species is in large ponds and shows zonation of sedges and grasses. — Water Crowfoot Association: The facies of this type is *Ranunculus circinatus* (= *Batrachium trichophyllum*) with such species as *Nasturtium officinale*, *Cardamine hirsuta*, *Veronica americana* and *V. Anagallis* associated with it. — Stonewort Association: Pools and small lakes, according to POUND and CLEMENTS, who have been followed in general in the description of the foregoing associations, possess a characteristic vegetation in which four species of *Chara* enter largely, viz: *Chara contraria*, *C. foetida* var. *longibracteata*, *C. fragilis* and *C. coronata*. The other plants present are *Potamogeton* and *Naias flexilis*.

*Algal Associations and Limnoplankton.* Certain stagnant pools in the valley of the Middle Loup River, Nebraska, besides supporting *Lemna minor*, *L. trisulca*, *Spirodela polyrhiza*, *Riccia fluitans*, *Utricularia vulgaris*, *U. minor*,

*Zannichellia palustris*, *Zygnema cruciatum* and species of *Chara* showed the following algae[1].

Chroococcaceae.

Merismopedia glauca Naeg.
» violacea Breb.
Chroococus cohaerens Naeg.

Nostocaceae.

Oscillaria (several species).
Nostoc pruniforme Ag.

Palmellaceae.

Scenedesmus caudatus Corda.
» dimorphus Kg.
Scenedesmus obtusus Meyen.
Pediastrum angulosum Ehr.
» Boryanum Turpin.
Raphidium polymorphum Fres.
Polyedrium trigonum Naeg. var. punctatum Kirch.
Protococcus viridis Ag.
Euglena viridis Schrank.

Desmidiaceae.

Docidium baculum Breb.
Cosmarium bioculatum Breb.
» conspersum Ralfs.
» Meneghinii Breb.
» nitidum De Not.
Cosmarium pulcherrimum Nord.
» undulatum Corda.
Euastrum verrucosum Ehrb.
Staurastrum gracile Ralfs.
» polymorphum Breb.

Diatomaceae.

Cymbella gastroides Kutz.
Navicula viridis Ehr. var. amphigompus Ehr.
» major Kutz.
» producta W. Sm.
Pleurosigma intermedium W. Sm.
Gomphonema clavatum Ehr.
Melosira varians Ag.
Gomphonema constrictum Ehrb.
Cocconeis pediculus Ehr.
Epithemia gibba Kutz.
» turgida Ehr.
Synedra ulna Nitsch.
Fragilaria Harrisonii W. Sm.

## 6. The intruding Forests of the Foothills.

The Great Plains have no indigenous forest flora, but the trees have been derived from two sources of supply the forests of the Mississippi basin and the forest of the Rocky Mountains represented in the foot-hills. The two elements as previously described meet in the valley of the Niobrara where according to BESSEY *Juglans nigra* and *Pinus ponderosa* var. *scopulorum* mingle.

The deciduous leaved forest trees are found in their most typic forms only along the large rivers. Their extension eastward has followed the water

1) WEBBER, H. J.: The fresh-water Algae of the Plains. American Naturalist XXIII (1889): 1011—1013.

courses [1]. They do not form true forest growth but represent the tongue-like extensions of the eastern forested areas. Tracing the western limits of the species of trees derived from the east we find the following extend farthest west in the north central states: *Fraxinus viridis* (= *F. lanceolata*), *Celtis occidentalis*, *Ulmus americana*, *Juniperus virginiana*, *Quercus macrocarpa*, *Populus monilifera* (= *P. deltoides*) and *Negundo aceroides* (= *Acer Negundo*). The last two can exist in the prairies because they grow on the river banks where the supply of water is abundant. In the south central states *Quercus obtusiloba* (= *Q. minor*) and *Q. marylandica* (= *Q. nigra*) replace *Quercus macrocarpa*. *Celtis occidentalis*, *Ulmus americana* and *Juniperus virginiana* extend farthest west into the Texas plateau, meeting and mingling there with *Sapindus Drummondii*, *Juglans rupestris*, *Prosopis juliflora* and the other southern and western species.

The evergreen forests characteristic of the Rocky Mountains have not extended eastward as rapidly as the eastern forests have extended westward, but are confined wholly to the foot-hills and to the country. Eight species of trees have entered the plains of Nebraska from the Rocky Mountains by way of Pine Ridge and Cheyenne Ridge. These are at first *Pinus ponderosa* var. *scopulorum*, *Shepherdia* (*Lepargyraea*) *argentea*. The other trees which have entered from the west have followed one or the other of these two ridges. Thus *Populus tremuloides*, *P. angustifolia*, *Acer glabrum*, *Betula occidentalis* follow Pine Ridge. On Cheyenne Ridge, *Populus acuminata* has pushed in from the Wyoming foothills and the mountain mahogany *Cercocarpus parvifolius* has pursued the same course [2].

It remains shortly to distinguish the associations of the forests in these territories, following POUND and CLEMENTS for Nebraska, in considering firstly the *River Bluff Formation*. This is most extensive and characteristic. It is typic of the bluffs of the Missouri and other large streams. Two types are known, the red oak- and the bur oak association.

The Red oak-Hickory Association is constituted by the following trees *Quercus rubra*, *Carya alba* (= *Hicoria ovata*), *Ulmus americana*, *Fraxinus viridis*, *Juglans nigra* and as other species occur this type is both variable and heterogeneous.

In the lower Missouri Valley Quercus macrocarpa, Q. coccinea, Q. alba, Carya porcina (= Hicoria glabra), C. amara (= Hicoria minima) are occasional intruders. In places the elm-ash-walnut facies are established and become typic of the greater part of the formation. These three facies are broken by the incursion of such invaders as Celtis occidentalis, Acer dasycarpum, Gymnocladus canadensis (= G. dioica), Crataegus mollis, Zanthoxylum americanum, Cercis canadensis, Ostrya virginiana. Ulmus fulva is often associated with its congener U. americana which it may rarely replace. Gleditschia triacanthos, Juniperus virginiana, Platanus occidentalis are scattered here and there. The role of lianes is an important one. Smilax hispida grows in the

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1) KELLOGG, ROYAL S.: Forest Belts of western Kansas and Nebraska, U. S. Forest Service. Bulletin 66. (1905).

2) See BESSEY, CHARLES E.: Are the Trees Receding from the Nebraska Plains. Garden and Forest X: 456.

deep woods. Ampelopsis (Parthenocissus) quinquefolia, Vitis vulpina, Rhus radicans grow at the forest edge. Menispermum canadense, Sicyos angulatus, Clematis virginiana, Echinocystis lobata also occur. — The secondary layer of shrubs and small trees is never well developed in this formation. Two climbers occur Apios tuberosa, Clematis Pitcheri and the following grasses scattered in patches: Cinna arundinacea, Asprella (Hystrix) hystrix.

The lower herbaceous layer in spring is characterized by Phlox divaricata, Erythronium albidum, E. americanum, Viola scabriuscula, Aquilegia canadensis (on steep bluffs), Cypripedium pubescens (rare), Orchis spectabilis (rare), Claytonia virginica, Dicentra cucullaria, D. canadensis. Sanguinaria canadensis and Caulophyllum thalictroides haunting secluded dells are rarely seen in the woods. The estival-serotinal aspect is heterogeneous, consisting of Sanicula marylandica, Cryptotaenia canadensis, Osmorrhiza longistylis, Geum canadense, Acalypha virginica. Parietaria pennsylvanica, Cystopteris fragilis, Adiantum pedatum also occur.

The Bur oak-Elm-Walnut Association has much in common with the preceding into which it grades. It is characterized by the disappearance of both *Quercus rubra* and *Carya alba*, which are replaced chiefly by facies of bur oak *Quercus macrocarpa* and elm *Ulmus americana*, in which the walnut *Juglans nigra* is often abundant. A large number of eastern trees have likewise dropped out, viz: *Aesculus glabra*, *Amelanchier canadensis*, *Asimina*, *Betula nigra*, *Cercis*, *Crataegus mollis* and *Staphylea trifolia*. In places especially on steep overhanging bluffs along the Missouri occur *Juniperus virginiana*, *Tilia americana*, *Ostrya virginiana*, *Zanthoxylum americanum*. Along the bluffs grow *Shepherdia argentea*, *Prunus demissa*, *Amelanchier botryapium*.

An interesting modification of this association is found on the coteaus of eastern Dakota (Plateau du Coteau du Missouri) extending into Canada. *Acer saccharum* has found a lodgement in some of the canyons on the eastern margin of the coteaus and with *Quercus macrocarpa*, *Ulmus americana*, *Tilia*, *Ostrya* forms a characteristic forest. The common shrubs are *Corylus americana*, *Rosa* sp., *Prunus virginiana* and *americana*. The trees of this district· are crooked, gnarled, low and spreading, in fact it is a brush thicket. The undershrub layer and the climbers of the two forest associations considered are practically the same, although certin of the eastern species of shrubs and herbs have entirely disappeared.

*Pine Ridge and Pine Bluff Formation.* This formation is characterized by a single facies *Pinus ponderosa* var. *scopulorum*. Open woodland of this species occur on exposed bluffs, ridges etc. Under such conditions, the individuals are medium-sized. The trees are dotted here and there in the thin grassy vegetation. In some places trees of *Juniperus virginiana* are intermingled. In the pine forest secondary species are absent, although such herbs as *Pirola chlorantha*, *P. secunda*, *Pterospora andromedea* are exceptions.

Lower down the pine is intermingled with Fraxinus viridis, Ostrya virginiana, Celtis occidentalis, Ulmus americana, Populus monilifera, Salix amygdaloides and the montane species Acer glabrum, Populus tremuloides, Betula occidentalis with a shrubby layer of Prunus demissa, Amelanchier alnifolia, Sheperdia argentea, Rosa Fendleri, Ribes oxyacanthoides, R. cereum, R. aureum, R. floridum, Vitis vulpina and Rhus radicans, R. trilobata with Symphoricarpos pauciflorus, S. occidentalis and the vine Ampelopsis (Parthenocissus) quinquefolia. The herbs of especial

interest are Corallorhiza multiflora, C. striata, Erigeron subtrinervis, Arnica cordifolia, Calochortus Nuttallii, C. Gunnisoni, and Zygadenus elegans [1]).

In north central Colorado, according to RAMALEY this formation is characterized by the rock pine Pinus ponderosa var. scopulorum, Juniperus scopulorum is rare. The vegetation in general is sparse, probably not over one fourth of the ground surface is covered with plants and the light brown and pink of the granite gives color to any near view. The species in the order of their abundance are Pentstemon humilis, Geranium Fremontii, Harbouria (Cicuta) trachysperma, Scutellaria Brittoni, Artemisia frigida, A. gnaphaloides, Potentilla glandulosa, Erysimum asperrimum, Anemone patens var. Nuttalliana (= Pulsatilla hirsutissima), Oxytropis Lambertii, Lesquerella (Vesicaria) montana, Mertensia lanceolata, Heuchera parviflora, Townsendia grandiflora, Opuntia polyacantha (= O. missouriensis) and such shrubs as Ribes pumilum, Jamesia (Edwinia) americana, Cercocarpus parvifolius.

*Springbranch-Canyon Formation.* This is characteristic of deep canyons with precipitous sides and numerous springs. Three types may be recognized, viz. linden type, paperbirch type, *Pseudotsuga* type.

The Linden-Cedar-Ironwood Association are marked by *Tilia americana*, *Juniperus virginiana*, *Ostya virginiana*, *Fraxinus pubescens* (= *F. pennsylvanica*). One or two facies only may occur on account of the shut-in character of the canyon, while on the bluffs all the facies may be present. At the base of bluffs and along streams there are thickets composed of *Cornus asperifolia*, *C. stolonifera*, *C. sericea*, *Amorpha fruticosa*, associated with which are *Sambucus canadensis* and *Zanthoxylum americanum*.

The canyons with the Paper-birch Association are confined to a narrow strip of country on either side of the Niobrara River. The canyons are invariably narrow and precipitous. The facies of this association is *Betula papyrifera*. The individuals are tall and strict and stand above the other trees; *Juniperus virginiana*, *Ostrya virginiana*, *Fraxinus pubescens*. Along the upper edges of the canyons, the usual thickets of *Prunus americana*, *P. demissa*, *Symphoricarpos occidentalis*, *Ribes aureum* occur. On the shady canyon sides grow *Elymus strictus*, *Heuchera hispida*, *Campanula rotundifolia* and *Arabis nudicaulis*.

The third type exists in north central Colorado and may be called appropriately the "Canyon Forest Formation". The vegetation extends along the stream banks, wherever there is a narrow canyon. The facies consists of *Pseudotsuga* and *Salix*.

The secondary species in shady localities are Acer glabrum, Rhus Rydbergii, Populus tremuloides, Potentilla fruticosa, Prunus melanocarpa, Physocarpus Torreyi (= Opulaster monogynus), Ribes valicola (= R. saxosum), Clematis eriophora, Hydrophyllum Fendleri, Galium triflorum, Smilacina stellata. Growing in more sunny situations are the same pine and junipers, Juniperus (Sabina) scopulorum and J. sibirica, Symphoricarpus occidentalis, Rhus trilobata, and Ribes pumilum. The plants immediately along the streams are Populus angustifolia, Alnus tenuifolia (= A. incana var. virescens), Mertensia ciliata, Heracleum lanatum, Iris missouriensis and Dodecatheon radicatum.

*Alluvial Island Formation.* The islands are sand-bars which have been captured by trees. They exist in all the large rivers of the prairie region.

1) See BESSEY, CHARLES E.: Some characteristics of the foothill Vegetation of western Nebraska. American Naturalist XXXII: 111.

*Salix cordata* and *Populus monilifera*, both fast growing trees, are prevailing. In the lower stretches of the Missouri, *Populus monilifera* prevails; at the mouth of the Niobrara *Salix cordata* is most prominent and exclusive; elsewhere the two trees may be in association. The secondary layers are almost entirely lacking. *Salix fluviatilis* grows at the water's edge, with *Amorpha fruticosa; Negundo* occurs in open places while back in the formation grow *Cornus* shrubs and *Ribes gracile* with swampy vegetation of *Cicuta maculata, Scirpus atrovirens, Asclepias incarnata* and *Lythrum alatum*. A loose grass covering exists on many of the islands consisting of *Elymus virginicus, Muhlenbergia racemosa* and *Poa pratensis*.

## 2. Rocky Mountain Region.

The flora of the Stony or Rocky Mountains is a complex one largely derivative. The principal forest trees as we have shown (pages 244—250) are Pacific coast species that have migrated from a center located somewhere between northern central of California and Puget Sound. The alpine species show a strong northern character, and in all probability, they reached the region during, or after, the final close of the glacial period. Other species have wandered in, as elements of the Mexican flora, while still others (a small percentage), are endemic to the mountains and probably originated in them. Two districts may be distinguished, a northern, or Dominion District, situated above a point represented by the headwaters of the Saskatchewan River and Milk River (a tributary of the Missouri) on the east, and Clarke's River, a tributary of the Columbia, on the west: and a southern (Park Mountain District) extending south from this point into northern New Mexico. An eastern outlobe is the Black Hills Territory.

The flora of the Park Mountains is continued southward into the mountains of New Mexico and southwestern Texas, which are isolated from each other by considerable stretches of arid country with a flora characteristic of the Great Basin, or the Mexican tableland. These areas are shown on the general map and a district might be established to include this flora. As these mountains are separated by wide intervals of desert country from the main Rocky Mountain mass and as the Rocky Mountain vegetation is likewise broken into more or less disconnected masses found only on the higher mountain slopes surrounded by a sea of Great Basin, or Mexican arid plant types, it has been thought best to treat each of these separated mountainfloras, as well, as those of Rocky Mountain affinity (as delimited on the map) in central Nevada with the phytogeography of the Great Basin and Mexican floristic regions.

### A. Northern Dominion District[1]).

Although the Selkirks and the Rocky Mountains are orographically of the same system, yet floristically there is a considerable difference, because

1) See plate I: Mt. Stephen in the Rocky Mts. of Canada.

the former mountains are more humid than the latter and because the snow fall is heavier, so that there are few plants in flower in early summer, but by July and August the mountain slopes, the borders of mountain brooks and the high meadows are bright with flowers.

As the country included in this district has not been wholly explored and as large tracts are, therefore, geographically unknown, we are far from possessing complete information about the flora. The following notes practically sum up in general way our knowledge of the vegetation of the district[1].

*Coniferous Forest Formation.* This varies in different localities. The following trees enter into this formation in the Rocky Mountains: *Pseudotsuga Douglasii* (= *P. taxifolia* = *P. mucronata*), which occurs on the eastern slopes of these mountains about the mouth of the Kananaskis and up the valley of the Bow River. In the dry southern portion of the interior it is confined to the higher uplands between the various river valleys. It is absent from the higher portions of the Selkirks. Northward, however, it comes down to the general level of the country. — The western hemlock *Tsuga Mertensiana* (= *T. heterophylla*)[2] occurs on the coast and follows up the Fraser and other rivers to the limit of abundant rainfall. It appears in the Selkirk and Gold ranges and is found on the west slopes of the Rockies, while *Tsuga Pattoniana* (= *T. Mertensiana*) is an alpine species in the fastnesses of the Selkirks. — *Thuja plicata* (= *T. gigantea*), is unknown in the dry central plateau but is found in the damp valleys of the Selkirk and Gold Range mountains. — *Picea Engelmanni* is the prevailing forest tree of the Canadian Rocky Mountains (see plate I) and appears to characterize the interior plateau forming a dense stand on the mountains. Northeastward, where it mingles with *Picea alba* (= *P. canadensis*), its limits are indefinable. It borders the streams and swamps in the northern portion of British Columbia at 2,500 to 3,500 feet altitude. — *Abies subalpina* (= *A. lasiocarpa*) grows abundantly in the Gold and Selkirk ranges and in the Rocky Mountains east of McLeod's

1) The writer is indebted to the botanic explorations of Miss EDITH FARR, Mrs. CHARLES SCHÄFFER, Messrs. CHARLES H. SHAW, M. H. JACOBS, STEWARDSON BROWN, E. NEWTON HARVEY and the late EDWARD R. HEACOCK of Philadelphia for information about the plants of the Canadian Rockies and Selkirk mountains. See also, VAN BRUNT, CORNELIUS: The wild Flowers of the Canadian Rockies. Transactions Massachusetts Horticultural Society. 1898: Part I, 182; FARR, EDITH M.: Contributions to a Catalogue of the Flora of the Canadian Rocky Mountains and the Selkirk Range. Contrib. Bot. Lab. Univ. of Penna (1907) III: 1—88; BROWN, ST. and Mrs. CHARLES SCHÄFFER: Alpine Flowers of the Canadian Rocky Mountains 1908; WHEELER, A. O.: The Selkirk Range Vol. I, text: Vol. II, maps Ottawa 1905, see especially the appendix pages 399—404.

2) A most unfortunate confusion of names is found in the synonymy of the two hemlocks of the western states. The western hemlock in the older systematic works is designated Tsuga Mertensiana Engelmann! (not Carrière), but other botanists call it Tsuga heterophylla (Raf.) Sarg. The mountain hemlock long designated Tsuga Pattoniana (A. Murr.) Sénélacuze, becomes Tsuga Mertensiana (Bong.) Carr. In order to prevent this confusion throughout this work, the two hemlocks are quoted thus: Western coast hemlock, Tsuga Mertensiana (= T. heterophylla); mountain hemlock, (Tsuga Pattoniana) (= T. Mertensiana).

Lake. In places, it occurs only in scattered groves and crosses the mountains in the Peace River country and enters that between Lesser Slave Lake and the Athabasca River. — The Russell Mountains at the forks of the MacMillan River, a tributary of the Pelly River, which empties into the Yukon at 137° W. Long., 63° N. Lat., are spurs of the northern Rocky Mountains. In the canyons and along the small streams of these mountains, the white spruce, *Picea alba* (= *P. canadensis*) is abundant extending up the mountain sides on northerly exposures to about 2,000 feet (610 m) and on southerly to 2,500 to 3,000 feet (915 m). At higher elevation, it is outnumbered by *Abies subalpina* (= *A. lasiocarpa*). The deciduous trees are *Populus balsamifera*, *P. tremuloides*, abundant along the banks of Russell Creek and on the benches associated with *Betula alaskana*, while on hot exposed benches, *Pinus Murrayana* is abundant [1]. — *Pinus ponderosa* reaches latitude 51° 30″ in the valleys near the upper portion of the Columbia River and extends to the Selkirk and Gold ranges. It forms open groves in the valleys, where it is sometimes exclusive, and stretches up the slopes of the Mountains and upon the plateaux to an elevation of 3,000 feet where it is replaced by *Pseudotsuga Douglasii* and *Pinus Murrayana* (= *P. contorta* var. *Murrayana*). This pine densely covers great areas on the eastern slopes of the Rocky Mountains northward, while in the southern part of British Columbia, it is found on those parts of the plateau and hills which rise above 3,500 feet, but it never reaches timber-line. *Larix occidentalis* is found in the Rocky Mountains and in the valleys of the Gold and Selkirk ranges, its limit there being determined by that of abundant rainfall. *Larix Lyallii* grows at an elevation above 7,000 feet near Lake Louise, B. C. and elsewhere, and is the distinctive tree of this phytogeographic district. — *Populus tremuloides* abounds in all parts of the district characterizing some of the fertile lands. In the southern dry portions, it usually grows on areas denuded by fire and on the dry mountain slopes while *P. balsamifera* is a characteristic tree of the river valleys.

The valley of the Kootanay River is characterized by open woods consisting of *Pinus ponderosa*, *Pseudotsuga*, *Larix occidentalis* with *Purshia tridentata* and *Balsamorhiza sagittata*, but near the upper Columbia Lake a denser forest prevails of which the black or scrub pine, *Pinus Murrayana* and Engelmann's spruce, *Picea Engelmanni*, form a large part, and these trees form the forest growth of the Rocky Mountains about the great bend of the Columbia River. — Northward to the headwaters of the Fraser River the same trees constitute the forest growth, viz: *Pinus*, *Picea*, *Pseudotsuga Douglasii* (which there reaches the northern limit) *Populus tremuloides*, *P. trichocarpa*, *Betula papyrifera*, *Juniperus virginiana* with such shrubs as *Amelanchier alnifolia*, *Sorbus sambucifolia*. The Rocky Mountain country north of this

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1) Osgood, Wilfred H.: Biological Investigation in Alaska and Yukon Territory. U. S. Bureau of Biological Survey. *North American Fauna No. 30 (1909): 70.*

is practically unexplored. Eastward of the Rocky Mountains proper in the country drained by the headwaters of the Peace and Athabasca rivers the forest vegetation consists of *Picea Engelmanni*, *Pinus Murrayana*, *Abies subalpina* (western species) and the following trees of extensive eastern range, *Picea alba*, *Populus tremuloides*, *P. balsamifera*, *Betula papyrifera*, *Larix americana* [1].

The shrubs beneath the trees in this district are Sambucus pubens, S. melanocarpa, Vaccinium membranaceum, Sheperdia argentea, Ribes laxiflorum, R. echinatum, Menziesia glabella, Sorbus sambucifolia, Juniperus sabina var. procumbens, Taxus brevifolia, Vaccinium ovalifolium, Berberis repens (= B. aquifolium), Fatsia (Echinopanax) horrida, Ledum latifolium, Cornus canadensis, Acer glabrum, Rhododendron albiflorum, Viburnum pauciflorum, Amelanchier alnifolia. The undershrubs Ribes lacustre, R. prostratum occur on the moraines or along glacial streams, while Vaccinium microphyllum (= V. erythrocarpum), is found on rocky aretes in the district with Vaccinium ovalifolium.

The moist ravines of the Selkirks are filled with an almost impenetrable undergrowth of which the spiny Fatsia (Echinopanax) horrida is a prominent element, together with Pachystinna myrsinites, Lysichiton kamtschatcense, while the long beards of dark lichens, Alectoria jubata var. prolixa, Alectoria sarmentosa, Usnea barbata var. hirta festoon the trees. Evernia vulpina, a yellow lichen, epiphytic on trees, is also conspicuous in the forests of the Canadian Rocky Mountains. The mosses of the woods are Philonotis fontana, Dicranum fuscescens (on rotten logs), Hypnum Schreberi while the following fern plants form an important element of this formation growing on the forest floor: Lycopodium complanatum, L. annotinum, Nephrodium (Aspidium) spinulosum var. dilatatum, Pteris aquilina var. lanuginosa, Equisetum pratense, Aspidium lonchitis, Nephrodium dryopteris.

*Sub-alpine Coniferous Forest Formation.* In cool and sub-alpine localities *Abies subalpina* forms extensive groves (Abies subalpina Facies), while *Pinus albicaulis* and *Larix Lyallii* abound only at the upper limit of arboreal growth which ranges from 6,000 to 7,000 feet (Pinus albicaulis Facies). The succession of trees species seems to be in general, as follows: *Larix Lyallii* Parl., strictly alpine; *Abies subalpina* Engelm. (= *A. lasiocarpa* Hook.), alpine and sub-alpine, and extending downward to the higher and cooler valleys; *Picea Engelmanni* Engelm. and *Pinus Murrayana* "Oreg. Com.", sub-alpine and extending downward, *Thuya plicata* Don. (= *T. gigantea* Nutt.), west slopes only; *Pseudotsuga Douglasii* Carr., lower valley on both slopes; *Larix occidentalis* Nutt., base of mountains on the west.

*Bog Formation.* The plants of sphagnum bogs are of an arctic-boreal character and have many species already described above (*Kalmia microphylla*, *Viola labradorica*, *Rubus arcticus*, *Empetrum*, *Mimulus moschatus*, *Polygonum viviparum*, *Bryanthus empetriformis*, *Sphagnum Russowii* and *Sphagnum acutifolium* are the bog mosses of the Selkirk country. The morainic deposits,

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1) For additional details the reader is referred to DAWSON, GEORGE M., Note on the Distribution of some of the more important Trees of British Columbia. Geological and Natural History Survey of Canada. Report of Progress for 1879—80, p. 167—177 B. with map; also Report of Progress for 1876—77, p. 17—149; DAWSON, GEORGE M.: Preliminary Report on the physical and geological Features of that Portion of the Rocky Mountains between latitudes 49° and 51° 30′. Part B. Annual Report 1885. Geol. & Nat. History Survey of Canada.

meadow-like as to vegetation, are occupied by *Epilobium latifolium*, *E. luteum*, *E. leptocarpum*, *Vaccinium membranaceum*, *Mimulus Lewisii*, *Cryptogramma acrostichoides*, *Echinospermum floribundum*, *Bryanthus*, *Cassiope*, *Dryas Drummondii*, *Castilleia miniata*, *Arnica cordifolia*, *Valeriana sitchensis* and as snow plants, *Pulsatilla occidentalis* and *Erythronium grandiflorum*.

Avalanche Slide Formation. A conspicuous landscape feature of the Selkirks, as distinguished from the main Rockies, according to Merkel H. JACOBS, are the avalanche slides the bright green vegetation of which contrasts strongly with the dark green of the forested slopes. The vegetation of these slides consists of dense masses of alder, Alnus sinuata (= A. viridis var. sinuata), willows and young birches, which alone survive in the usual track of avalanche snow, because they bend without breaking until they come to occupy such avalanche paths exclusively. The vegetation of these slides suggests that of Mount Katahdin in Maine with slide-covered thickets of Alnus viridis; the alder thickets of Roan Mountain, N. C. (see page 496); the alpine scrub of the mountains of Japan, where Pinus parviflora and Alnus viridis abound and the subalpine bushland of Europe[1].

Torrent Fan Formation. A torrent fan is a loose mass of sand gravel and boulders forming a level delta-like deposit of considerable extent at the foot of a waterfall or torrent. Such soil is peculiarly suited to herbaceous plants, such as, Saxifraga aizoides, Tofieldia glutinosa, T. palustris, Cypripedium parviflorum, Dryas Drummondii, Dryas octopetala, Parnassia parviflora, Antennaria lanata, Orchis rotundifolia, Sisyrinchium angustifolium; Primula Maccalliana, Pinguicula vulgaris, Carex pseudoscirpoidea and Juniperus prostrata. Such an assemblage of plants is found near Emerald Lake in the Selkirk Mountains.

*Alpine Plant Formation.* The summits of the Selkirk Mountains above 6,000 feet elevation display truly alpine conditions. They are for the most part bare hills covered solely with lichens, a few grasses and herbs that adopt the alpine habit. These summits suggest strongly the alpine peaks of Switzerland and the Tyrol with the same variety of exposure and the vegetation of much the same aspect.

Some of the plants of these hills, as far as known between 6,000 and 8,000 feet elevation, are: Vaccinium microphyllum (= V. erythrocarpum), Phleum alpinum, Delphinium bicolor, Pedicularis racemosa, *Carex nigricans*, *Bryanthus (Phyllodoce) glanduliflorus*, *B. (P). empetriformis*, *Silene acaulis* (forming alpine mats), while the plants above 7,000 feet are Senecio lugens, Gentiana glauca, Aplopappus Brandegei. The bare hills of the Il-ga-chuz range farther north rise from a surface dotted with small ponds and lakes. The vegetation is quite alpine consisting of Sedum Rhodiola (= R. rosea), Erigeron salsuginosus, Pedicularis euphrasioides, P. groenlandica var. surrecta, Menziesia glandulifera, Dryas octopetala, Campanula lasiocarpa and Gentiana glauca.

The following plants are true alpine species of the Selkirks:

Botrychium simplex E. Hitchcock.
Phegopteris alpestris Hoppe.
Lycopodium Selago L.
» sitchense Rupr.
Festuca brachyphylla Schultes.
Trisetum subspicatum L.
Carex atratiformis Britton.
» pseudoscirpoidea Rydb.
» rupestris Rydb.

Juncus Mertensianus Bong.
» Parryi Englm.
Luzula (Juncoides) spicata DC.
Tofieldia borealis Wahlenb. (= T. palustris [Huds.).
Oxyria digyna L.
Silene acaulis L.
» Lyallii Wats.
Alsine laeta Richards.
Arenaria capillaris Poir. var. nardifolia Ledeb.

[1] WARMING. Oecology of Plants: 215—217.

Anemone Drummondii Wats.
» patens. L. var. Nuttalliana Gray.
Ranunculus nivalis L. var. Eschscholtzii Wats. (= R. Eschscholtzii Schl.).
» alpeophilus A. Nelson.
» pygmaeus Wahl.
Draba nivalis Liljb.
Heuchera glabra Willd.
Leptarrhena amplexifolia Sternb.
Mitella Breweri Gray.
Saxifraga caespitosa L.
» cernua L.
» rivularis L.
Viola canina L. var. adunca Gray (= V. adunca Smith).
Dryas octopetala L.
Rubus arcticus L. var. grandiflorus Ledeb.
Sibbaldia procumbens L.
Oxytropis (Aragallus) alpicola Rydb.
Epilobium anagallidifolium Lam.
Bryanthus glanduliflorus Gray.
Gaultheria humifusa Graham.
Androsace subumbellata A. Nelson.
Castilleia pallida Kunth.
Veronica alpina L. (= V. Wormskjoldii R. & S.).
Myosotis alpestris Schmidt.
Aplopappus Lyalli Gray.
» (Pyrrocoma) Brandegei A. Gray.
Erigeron simplex Greene (= E. uniflorus Hook.).
Senecio triangularis Hook.
Taraxacum rupestre Greene.
» scopulorum Gray.

In concluding this sketch of the vegetation of the Canadian Rocky Mountains it can be said that the alpine plants are not confined exclusively to the mountains above timber-line. Owing to the presence of large glaciers that descend into the valleys the presence of large amounts of treeless morainic deposits and varied conditions of soil and light exposures many alpine plants descend to the treeless areas much below the true altitudinal limit of the arborescent species.

## B. Southern Park Mountain District.

This district comprehends the Stony, or Rocky mountains south of the international boundary. The ranges have a general north and south trend and between them there are valleys of larger or smaller size known as parks. Above the timber-line the peaks are naked, below on the flanks of the mountains, great forests stand, and often spread over elevated plateaus, while the valleys are beautiful prairies or parks. Small and picturesque parks exist sometimes called gardens. This is, therefore, a land of mountain ranges and valleys, of peaks and parks, of naked crags, forest clad mountains, lakes and plateaus (see ante page 106).

### 1. The southern Rocky Mountains Forests.

#### a) Coniferous Forest Formations.

The forest formations of this district are essentially coniferous. Here, as compared with the eastern deciduous forest region, there is a more equable distribution of temperature throughout the year, with winter rains and dry summers.

The deciduous element is largely confined to edaphic situations along the water courses [1]. Timber line seems to exist in the Sawatch and other ranges

1) The writer is indebted to the following mentioned in the Bibliography page 71—74: LEIBERG, J. B.; AYRES, H. B.; TOWN, F. E.; Tweedy, FR.; BRANDEGEE, T. S.; JOCK, JOHN G.

at an elevation between 11,000 and 12,000 feet. In the Yellowstone National Park timber line is at 9,600 feet elevation on the peaks and somewhat higher on the table-lands. In Colorado timber line as on Pikes Peak is at 11,500 feet and the altitudes of the belts mentioned for the Coeur d'Alene Mountains are much higher for the same belts in Colorado farther south. This fact should be born in mind, as it explains the apparent discrepancy in the member of feet given for the altitudinal distribution of each species.

The forest on many ranges of the northern Park Mountains exhibit three distinct types, viz: (1) the belt of *Pinus ponderosa*[1]), (2) the belt of *Pinus monticola*, (3) the belt of *Abies subalpina* (= *A. lasiocarpa*[2]). The Pinus ponderosa-belt does not extend above 2,900 feet although on warm southern exposures it may go as high as 4,700 feet. It consists of *Pinus ponderosa* (10 per cent.), *Pseudotsuga Douglasii* (70 per cent.), *Abies grandis* (15 per cent.), *Larix occidentalis*, *Pinus Murrayana*. The altitudinal limit of *Pinus ponderosa* as a timber tree is 3,500 feet above sea-level, while *Pseudotsuga* readily ascends to 4,500 feet on the slopes facing the south west and east. *Larix occidentalis* is a bench-land tree associated with *Pinus ponderosa* in such places. In the Bitterroot Mountains, *Pinus ponderosa* forms a belt reaching to 5,800 feet; in the canyons it extends from two to three miles above their outlet. On the east side of Bitterroot Valley, it fringes the tributary canyons sometimes with a pure growth[3]).

In the neighborhood of Pikes Peak, Colorado, *Pinus ponderosa* is the most abundant and widely distributed tree and is found from the lowest altitude (under 6,000 feet) up to above 10,000 feet where it is supplanted by the other species. In some places, it forms a true forest, but as a rule *Pseudotsuga Douglasii* is more or less plentifully associated with it and occasionally it occurs mixed with *Pinus Murrayana*. On south slopes, rocky ledges 8,000 feet to timber line 11,00 feet, *Pinus aristata*, *Pinus edulis*, *Picea Engelmanni*, *Picea Parryana* = *P. pungens*, etc. On the higher it is not so localized as in the lower slopes where it predominates on slopes facing the south, while *Pseudotsuga* is more plentiful on those facing the north. This is a marked feature in most of the canyons and gulches which extend in an easterly and westerly direction.

*Pinus ponderosa* is abundant at 8,000 feet in southwestern Colorado. According to BRANDEGEE *Pinus flexilis*, an uncommon tree here, grows with it at an altitude of 8,500 feet as do also *Abies grandis*, *A. Menziesii*, *Picea Engelmanni*, *Pseudotsuga*.

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1) In this belt always Pinus ponderosa, var. scopulorum (Editor.).

2) See also LEIBERG, JOHN B.: General Report on a botanical Survey of the Coeur d' Alene Mountains in Idaho during the Summer of 1895. Contributions U. S. National Herbarium V: 1—85. 1897.

3) PAMMEL, L. H.: Notes on the Flora, especially the forest Flora of the Bitterroot Mountains. Iowa Academy of Sciences 1904: 87—100 with 6 plates.

The undergrowth in the northern belts of Pinus ponderosa is noted for the absence of Menziesia ferruginea and M. glabella while Juniperus scopulorum, Salix Nuttallii (= S. flavescens), Alnus rhombifolia, Cercocarpus ledifolius, Amelanchier alnifolia, Crataegus Douglasii (C. brevispina), Prunus emarginata, Rhamnus Purshiana, Acer glabrum, Ceanothus sanguineus, C. velutinus, Cornus stolonifera occur in considerable frequency. In the Coeur d'Alene Mountains the sparse undergrowth consists of Holodiscus discolor, Ceanothus sanguineus, Philadelphus Lewisii and sedges Carex Geyeri.

In the Bitterroot Mountains according to PAMMEL in this forest belt are found with Pinus ponderosa the following: Rubus Nutkanus, Prunus demissa, Philadelphus microphyllus, Amelanchier alnifolia, Betula occidentalis, Geranium Fremontii, Berberis repens (= B. aquifolium[1]).

The principal species in this formation where Pinus ponderosa and Pinus flexilis are associated in the Pikes Peak country in Colorado are in spring, Arctostaphylos uva-ursi, Pentstemon secundiflorus, P. humilis, and as secondary species occur Draba streptocarpa, Pentstemon humilis var. roseiflora, Erigeron multifidus. The summer growing plants are Geranium caespitosum, Potentilla fissa, Arenaria Fendleri and in autumn occurs Gentiana affinis.

2. The Pinus monticola belt lies below 5,000 feet. It is predominant in many places. It is found especially between altitudes of 2,400 and 4,800 feet above sea level and reaches its greatest development between elevations of 2,800 and 3,500 feet. The principal trees are *Pinus monticola* (42 per cent.), *Larix occidentalis* (35 per cent.), *Thuja plicata*, *Picea Engelmanni*, western coast hemlock, *Tsuga Mertensiana*, *Abies grandis*. Mixed with these species are scattered individuals of *Pseudotsuga*, *Populus trichocarpa*, *Betula occidentalis*, *B. papyrifera*, *Salix Nuttallii*, *S. lasiandra*.

In northwestern Montana such a forest type occupies the middle slopes. The heaviest growth in this belt is on the level areas bordering the principal streams. Around Flathead Lake, Pinus monticola grows on lower Swan River and the South Fork of Flathead River together with Abies grandis, Thuja plicata, western coast hemlock Tsuga Mertensiana, mountain hemlock Tsuga Pattoniana. This belt of Pinus monticola occupies northern and eastern slopes and follows canyon bottoms from an altitude of 5,800 feet down to 2,400 feet.

The more common shrubs in the belt of Pinus monticola are Acer glabrum, Sambucus glauca, S. melanocarpa, Ceanothus sanguineus, C. velutinus, Cornus stolonifera, Rhamnus Purshiana and Rubus parviflorus. The upper areas toward the subalpine belt carry the densest undergrowth of over 80 per cent. of Menziesia ferruginea and M. glabella.

3. The Abies subalpina-belt exists above 5,000 feet. It is not a continuous forest being broken at intervals by grassy slopes or rocky crests. In the main *Abies subalpina* and *Pinus albicaulis* prevail. The subalpine belt covers all the forested slopes in the Bitterroot Mountains having a northern, or direct western exposure above 5,800 feet. The forest trees in the main canyons in the Bitterroot ranges are *Larix Lyallii*, *Abies subalpina* (= *A. lasiocarpa*), *Pinus Murrayana*, *P. albicaulis*, *Abies grandis*, *Picea Engelmanni*, *Taxus brevifolia*, mountain hemlock, *Tsuga Pattoniana*. A great variety of combinations are formed by these trees, but the alpine fir is everywhere the predominating tree. In descending to 3,300 feet its associates are *Pinus Murrayana*, *Picea Engelmanni*. In the Yellowstone Park *Abies subalpina* is

1) PAMMEL, L. H.: Notes on the Flora, especially the forest-Flora, of the Bitterroot Mountains. Iowa Academy of Science, 1905: 87—105.

nowhere abundant, while in the Teton Mountains this tree occurs about timber line on the northern slopes and follows streams down to lower elevations. *Pinus flexilis* occurs on exposed peaks. In Colorado *Abies subalpina* reaches up to the average timber line also extending well down the mountain sides on cold northern slopes. Here it is rare and locally distributed among *Picea Engelmanni* and occasionally with *Pinus Murrayana*, but never mingles with Abies concolor.

The subalpine belt presents four chief features. The first and most typic consists of a forest of medium density with little underbrush, the ground being covered with low shrubby Vacciniums, alpine sedges or rushes while Xerophyllum tenax forms dense swards. Litter is scanty and humus is practically absent. Forests of this character are found about 5,500 feet elevation mostly on ridges and slopes. The second aspect is a forest of great density one to two thousand trees to the acre with an abundance of litter. The third aspect is that of densely brush-covered areas with thin forest. The brush consists of Alnus viridis, Sorbus sambucifolia, Ledum glandulosum, Menziesia ferruginea, M. glabella, Rhododendron albiflorum with a large amount of litter and no humus. The edges of this belt are occupied by Vaccinium occidentale and Betula glandulosa. Above this belt for example in the Coeur d'Alene Mountains exists one where mountain hemlock, Tsuga Pattoniana and Pinus albicaulis are dominant. There is not much undergrowth, but Sorbus sambucifolia and S. occidentalis occur.

The subalpine coniferae in southwestern Colorado on southwestern slopes are mainly Picea Engelmanni and Abies grandis. These two species either together or in forests of one alone cover the western mountain slopes down to forests of Pinus ponderosa (9,000 feet). Picea Engelmanni is the only tree at timber line, but Abies grandis reaches very nearly as high. Pseudotsuga Douglasii (= P. taxifolia = P. mucronata) is not very common in southwest Colorado (9,000—7,000 feet) descending into the region of Pinus edulis and Juniperus occidentalis. Abies concolor is not seen on the western slope[1].

4. Still another type of forest is formed by the almost pure stands of *Pinus Murrayana* (Pinus Murrayana Facies). In northwestern Montana about Flathead Lake, this pine usurps the low morainic ridges leading from mountain spurs while *Pseudotsuga Douglasii* occupies sunny rocky slopes. The forests of the Yellowstone Park consist principally of *Pinus Murrayana*, the lodge pole pine, intermingled with groves of *Populus tremuloides*. The pine reaches its best development on the drier plateaus between 7,000 and 8,000 feet, here forming 90 per cent. of the forest[2].

The bulk of the forests in the Teton range consists of Pinus Murrayana with Populus tremuloides, Picea Engelmanni along streams between 7,000 and 10,000 feet. Pseudotsuga Douglasii (not abundant), Populus angustifolia (along streams in the valleys), P. trichocarpa (not common), Juniperus communis (very uncommon), J. virginiana (little found), Pinus flexilis (in exposed places, and on dry ridges from 7,500 feet upward).

The prevailing tree in northern Wyoming in the Bighorn Mountains is the lodge pole pine with Pinus flexilis scattered among it and in certain localities Picea Engelmanni makes a considerable growth, while Pseudotsuga Douglasii (= P. taxifolia) is rare. Pinus Murrayana in

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1) Brandegee, T. S.: The Flora of southwestern Colorado. Bulletin Geological and Geographical Survey of the Territories. Vol. II No. 3. Washington, June 6, 1876; see also Ramaley, Francis: Wild Flowers and Trees of Colorado 1909, pages 1—78, profusely illustrated.

2) Tower, G. E.: The reproductive Characteristics of Lodge-pole Pine. Proc. Soc. Amer. Foresters IV (1909): 84—106. The Plant World XII: 240.

Colorado is sometimes found in admixture mostly with Picea Engelmanni, but its most characteristic growth is found on those areas where it occurs alone or greatly predominates over other species. It is uncommon in Pikes Peak Forest Reserve. In Plum Creek Reserve, it is nowhere abundant and in South Platte Reserve, its distribution is peculiar and irregular. It grows most abundantly on the higher plateaus and on northerly slopes at altitudes ranging between 8,000 and 10,500 feet exceptionally reaching 11,000 feet, but never extending to the highest timberline. It is accompanied by a parasite Arceuthobium (Razuomofskya) americanum.

5. The principal tree of the valleys in the Flathead Forest Reserve is the larch, *Larix occidentalis;* whether this formation is widely distributed has not been determined. The western larch is essentially a bench-land tree associated with *Pseudotsuga*, *Pinus Murrayana*, *Abies grandis*, *Pinus monticola*, *Picea Engelmanni*, *Thuja plicata* and occasionally *Abies subalpina*, *Pinus ponderosa* and western coast hemlock, *Tsuga Mertensiana*, also certain deciduous trees. This type of forest gradually passes into that in which *Pinus monticola* predominates. As a tree the western larch does not tolerate shade and cannot reproduce itself unless an opening be made first in the forest.

Acer glabrum gives decided tone to the undergrowth of this forest type which consists of Philadelphus Lewisii, Holodiscus ariaefolius, Menziesia glabella, Taxus brevifolia, Spiraea betulaefolia (= S. lucida), Elaeagnus argentea, Cornus stolonifera, Sorbus sambucifolia, Viburnum pauciflorum, Shepherdia canadensis, Juniperus communis, J. sabina, J. scopulorum, Fatsia, Rubus Nutkanus, Ribes lacustre, Crataegus Douglasii, Sambucus melanocarpa and such plants of the lower layer as Berberis repens, Aralia nudicaulis, Cornus canadensis, Chimaphila, Pirola, Linnaea, Clintonia uniflora, Adenocaulon, Tiarella &c. — The characteristic non-tree species of the subalpine belt on Pikes Peak, according to T. D. A. Cockerell, are Aquilegia brevistyla (= A. saximontana), Phacelia sericea, Castilleja pallida, Pyrola chlorantha, Polemonium humile var. pulchellum (= P. scopulinum), P. mellitum, Atragene occidentalis, Erysimum asperum, Potentilla fruticosa, Rubus strigosus, Fragaria americana, Valeriana edulis, Carduus eriocephalus (= C. scopulorum), Achillea lanulosa, Helianthella Parryi, Senecio MacDougalii (= S. eremophilus), Pentstemon glaucus, Mertensia ciliata, Sedum rhodanthum, Zygadenus elegans, Thalictrum alpinum.

Other facies of the fir-, spruce- and pine associations are the following:

*Spruce-(Picea Engelmanni-) Facies. Picea Engelmanni* advances on the meadows of the Flathead Valley whereever small streams spread out over a level extent of land. The youngest trees are found on the hummocks in the meadows, nearer its borders are the older ones, which grade imperceptibly into dense forests of *Picea Engelmanni* associated with the spruce in the open edges of the dense forest are found *Populus angustifolia*, *P. tremuloides* and *Betula papyrifera*. In the dense woods the undergrowth is scanty, sometimes only one or two species are present. *Rhamnus alnifolia* is the most common plant in pure spruce growths, although *Cornus stolonifera* is often found. In the narrow strip of this forest along the streams nearer the mountains *Fatsia (Echinopanax) horrida* and *Veratrum californicum* are present[1]).

The *Picea-Pseudotsuga Facies* in Colorado consists of *Picea Engelmanni*, *Pseudotsuga Douglasii*, *Picea Parryana* (= *P. pungens*). *Pseudotsuga*

1) Whitford, Harry N.: The Forests of Flathead Valley, Montana. Botanical Gazette XXXIX; 194—218. March 1905.

ranges with the yellow pine with which it is usually found associated sometimes one preponderating; sometimes the other. It grows well at lower altitudes (6,000 feet) and the highest altitude at which it was noted was between 10,500 and 11,000 feet. On the lower altitudes and along canyons and gulches the red fir is found mixed with blue spruce as well as yellow pine and in its upper limits it is often scattered among *Picea Engelmanni* and *Pinus Murrayana* upon which is a parasite *Arceuthobium Douglasii.*

*Picea Engelmanni* white spruce, grows as almost pure forest but commonly some *Pinus Murrayana*, *P. aristata*, *Abies subalpina* are found mixed with it. Often extending down cool northern mountain slopes and following cold canyons and gulches in small numbers to 6,000 or 7,000 feet altitude, it is most abundant and seems most at home. It reaches its best development at an elevation between 10,000 and 11,000 feet covering the tops of mountains under timber line and forming a belt around the highest often up to 11,500 to 11,700 feet and extending in more or less dwarfed or stunted form according to exposure to the highest limit reached by trees.

*Picea Parryana* (= *P. pungens*), Colorado blue spruce, is uneven in its distribution and is confined to the lower altitudes where it is found along rivers and creeks or where the average amount of soil moisture is greater. It commonly occurs over the same territory occupied by *Pinus ponderosa* and *Pseudotsuga* which usually grow on the slopes while blue spruce more closely follows the water courses. As a rule it seems to range between 6,000 and 9,000 feet, where it never occurs as pure forest, generally being scattered among other species.

The Picea-Pinus Facies is typically represented in Colorado. It consists of two trees which constitute the facies, viz: *Picea Engelmanni* and *Pinus aristata*. *Pinus aristata* is usually found on ridges, rocky ledges from about 8,000 feet altitude to timber line (11,500 feet), but in favorable situations it may extend in twisted and dwarf specimens to 12,000 feet. It is often the chief tree on the upper parts of southern slopes of many mountains, the upper northern slopes being chiefly occupied by *Picea Engelmanni.*

Pinus aristata is not always present as an element, according to YOUNG, for it is absent almost entirely in the mountains of Boulder County, Colorado. Thuja plicata (= T. gigantea), the giant arbor vitae, a tree found generally west of the Cascade Mountains, in the Flathead Valley in the midst of the Rocky Mountains of Montana forms several isolated places a full stand of trees. It is usually found in moist places (Arbor Vitae Facies).

### b) Broad leaved Tree Formations[1].

*Populus tremuloides Formation.* The tree which constitutes the almost exclusive growth of this formation is found from levels of 10,500 to

1) At pages 200 and 242, the ancient presence of deciduous leaved trees in the Rocky Mountains has been considered, but see several recent papers viz.: COCKERELL, T. D. A., The fossil Fauna and Flora of the Florissant Shales. University of Colorado, Studies III (1906): 157—176; Some Results of the Florissant Expedition of 1908. The American Naturalist XLII (1908): 569—581; The Miocene Trees of the Rocky Mountains, do. XLIV (1909): 31—47.

11,500 feet in open woods, which show no trace of fire. Where the original timber has been destroyed it forms an almost pure growth.

Many species are associated with this tree, viz: Rosa Sayii, Fragaria glauca, Poa crocata (= P. nemoralis), Anemone globosa (= A. multifida), Festuca Thurberi (= F. scabrella), Pedicularis procera, Helianthella Parryi, Pentstemon glaucus, Frasera speciosa, Rudbeckia flava, Carex obtusata, Calochortus Gunnisoni, Castilleia confusa, Gentiana Parryi, G. acuta, &c. In the Davis mountains in Texas a thicket of Populus tremuloides is found along the northeast base of a high cliff near Livermore Peak and indicates a mere trace of a formation developed more extensively to the northeast [1]).

*Salix-Betula Formation.* The meadow-thicket formation consists of several willows, such as, *Salix Geyeriana*, *S. chlorophylla*, *S. glaucops*, *S. Bebbiana*, *S. monticola*, *Betula glandulosa*, *Potentilla fruticosa*.

The vernal aspect is due to Thalictrum alpinum, Carex aurea, Mertensia lateriflora and in summer grow Deschampsia caespitosa, Crepis runcinata, Lilium montanum, Thlaspi glaucum, Cerastium oreophilum. The autumn vegetation consists of Aster Geyeri, Gentiana acuta, Mertensia ciliata, Saxifraga birculus.

*Quercus-Cercocarpus Formation.* This is a foothill formation in the shape of a thicket along the eastern base of the mountains and down the ridges and gullies far out on the plains. *Cercocarpus parvifolius*, *Rhus trilobata*, *Quercus Gambelii*, *Q. utahensis* (= *Q. stellata* var. *utahensis*), *Prunus demissa* constitute the facies.

The species mentioned by CLEMENTS in association are numerous. Only a few are given below. Malvastrum coccineum, Oxybaphus (Allionia) hirsutus, Mentzelia nuda, Chrysopsis villosa, Gaura coccinea, Castilleia integra, Phacelia glandulosa, Verbesina encelioides, Mirabilis oxybaphoides, Woodsia mexicana, Notholaena Fendleri, while Rubus deliciosus, Holodiscus dumosus, Ribes cereum, R. leptanthum, R. pumilum are among the principal shrubs.

## 2. Meadows, Lakes and Bogs.

*Meadow- and Swamp Meadow Formation.* The plants of this formation cover the filled-in beds of old lakes and they resemble in the Flathead Valley and elsewhere swamps with similar edaphic situations in the eastern United States. Near the head of Ross Lake, for example, is a sphagnum meadow in which grow *Menyanthes trifoliata*, *Drosera rotundifolia*, *Potentilla palustris*, *Eriophorum polystachyon*, and *Betula pumila* [2]). — Other large meadows show this combination. These meadows are usually submerged during the spring and early summer months, when the melting snow of the mountains to the eastward swells the streams. These meadows, as previously stated, show a gradual encroachment of *Picea Engelmanni* upon them.

The meadow flora in the Yellowstone Park (7,500—9,000 feet) (2300—2740 m) consists of Stellaria umbellata (= Alsine baicalensis), S. (A.) longipes, S. borealis, Saxifraga punctata, S. integrifolia, Valeriana edulis, V. sylvatica, V. septentrionalis, Potentilla dissecta, P. gracilis, P. fruticosa,

1) BAILEY VERNON: Biological Survey of Texas. North American Fauna, No. 25, U. S. Biological Survey. 1905: 38.

2) WHITFORD loc. cit. p. 195.

Senecio triangularis, S. crassulus, Polygonum bistorta (= P. bistortoides), P. viviparum, Habenaria hyperborea, H. dilatata, Allium Schoenoprasum, A. brevistylum, Trifolium longipes, Pedicularis groenlandica, Rumex paucifolius, Zygadenus elegans while here and elsewhere over the hot spring geyser areas, the small streems are bordered by Parnassia fimbriata, Gentiana serrata and Mimulus luteus.

*Lake Formation.* The species of lake waterplants are as much the same as named before in this formation in the eastern states. A few examples may prove it.

The lakes in the Flathead Valley are shallow with a muddy bottom. In the center of such lakes are found Nuphar advena, Brasenia peltata, four species of Potamogeton, Myriophyllum and Hippuris. The sedge circumarea bordering the water of shallow ponds consists of Bromus Richardsoni var. pallidus, Muhlenbergia racemosa, Carex utriculata, C. viridula, C. hystricina, Calamagrostis caespitosa, Phalaris arundinacea, Juncus Rugelii, Scirpus lacustris var. occidentalis, Cicuta maculata and species of the genera Lobelia, Solidago and Dodecatheon.

The flora of the ponds and streams in the Yellowstone country consists of Ranunculus multifidus, Nuphar advena (rarely absent from muddy ponds), Nuphar polysepalum, Hippuris vulgaris, Ceratophyllum demersum, Sparganium simplex var. angustifolium, Sagittaria variabilis, Utricularia vulgaris, Potamogeton rufescens (= P. alpinus), P. perfoliatus, P. pectinatus. Subularia aquatica and Isoëtes Bolanderi are found on the bottom of ponds about Yellowstone Lake. Callitriche autumnalis (= C. bifida) is abundant and less so C. verna. Besides these may be mentioned Zannichellia palustris, Ruppia maritima, Marsilia vestita, Myriophyllum verticillatum and Polygonum amphibium. — At the outlet of Yellowstone Lake is a small pond a few feet in depth and several acres in extent. Submerged and growing on the bottom are Subularia aquatica, Elatine triandra, Isoëtes Bolanderi, Callitriche autumnalis, while floating on the surface are found Ranunculus multifidus, Polygonum amphibium, several species of Sagittaria, Sparganium, Lemna and Potamogeton. In the mud at the water's edge grow Elatine americana, Tillaea angustifolia, Krynitzkia (Allocarpa) californica and Limosella aquatica.

Red Rock Lake at an altitude of 10,100 feet (3,078 m) in Colorado shows the following circumareas, according to RAMALEY[1]. The aquatic circumarea is marked by Sparganium angustifolium, Potamogeton alpinus, Zannichellia palustris, Ranunculus aquatilis, trichophyllum (= Batrachium flaccidum) and Nuphar (Nymphaea) polysepala. The plants of the sedge circumarea are Deschampsia caespitosa, Hierochloa odorata, Carex siccata, C. utriculata, Juncus balticus, Caltha leptosepala, Sedum rhodanthum, Saxifraga hirculus, Dodecatheon pauciflorum, Elephantella groenlandica and Achillea lanulosa. The shrub association includes a few scattered specimens of Picea Engelmanni and Salix Bebbiana, S. chlorophylla, S. glaucops, S. lutea, Betula glandulosa, Arenaria sajanensis, Caltha leptosepala, Heracleum lanatum, Castilleia sulphurea, Pedicularis racemosa, Trollius albiflorus, Saxifraga nivalis and Erigeron salsuginosus. The trees of the surrounding forest in proximity to the lake vegetation are Abies subalpina (= A. lasiocarpa), Picea Engelmanni, Pinus flexilis, P. Murrayana, Juniperus sibirica, Populus tremuloides with which are associated such shrubs as Ribes parvulum, Arctostaphylos uva-ursi, Vaccinium oreophilum, Sambucus microbotrys while the herbs are Selaginella densa, Juncus Mertensianus, Arenaria pygmaea, Pulsatilla hirsutissima, Sedum stenopetalum, Lupinus alpestris, Thermopsis arenosa, Castilleia confusa, Pentstemon alpinus, Campanula petiolata, Achillea lanulosa, Antennaria parvifolia, Arnica cordifolia, and Erigeron trifidus.

*Bog Formation.* (Compare the swamp meadow described previously.) The bogs of the Yellowstone National Park are characterized by patches of low willows *Salix Geyeriana* with *Betula glandulosa* and *Potentilla fruticosa*, the most characteristic shrub of the mountains bogs.

1) RAMALEY, FRANCIS: Studies in lake and streamside Vegetation. University of Colorado, Studies VI: 133—168. Feb., 1909.

Travertine Deposits.

Mammoth Hot Springs, Yellowstone Park (Cleopatra Terrace) formed by hot spring algae. (Hot Spring Formation. Pinus Murrayana in background.

Massed in great profusion over the surface of the bogs are Gentiana serrata (= G. detonsa, G. Forwoodii, Senecio lugens, S. subnudus, Zygadenus elegans, Trifolium longipes, Polygonum viviparum, Parnassia fimbriata, Habenaria hyperborea, Pedicularis groenlandica, P. brodiaca, P. racemosa, Valeriana edulis, while as secondary species hidden beneath the taller ones are Stellaria (Alsine) borealis, S. longipes, S. crassifolia, Androsace filiformis, A. septentrionalis, Wyethia helianthoides is a striking plant and such grasses as Phleum alpinum, Bromus breviaristatus, B. ciliatus, B. Kalmii are found[1]).

## 3. Vegetation of the Geyser and Hot Springs.

This formation is confined to the Yellowstone Park. The alkaline nature of the soil and the warmth afforded by the hot spring and geyser areas have influenced the distribution of species to a marked extent. Such seashore plants as *Salicornia herbacea*, *Rumex maritimus* (= *R. persicarioides*) and *Triglochin maritima* are found. The barren soil supports few plants but where overlaid by other soil or where the species grow along streams occurs a luxuriant vegetation of *Chrysopsis villosa*, *Gnaphalium Sprengelii*, *Panicum dichotomum* var. *pubescens*. *Ruppia maritima* has been observed in water with 90° F. of heat. The small streams are filled with *Potamogeton pectinatus*, while *Botrychium ternatum* var. *australe* has never been observed out of hot spring soil. The bare geyserite supports *Spraguea umbellata*, *Castilleia minor*, *Orthocarpus luteus* and *Glyceria airoides*[2]).

The following plants have not been observed on soils other than that due to the hot springs:

Aplopappus uniflorus Torr. and Gray.
Lycopus virginicus L. var. pauciflorus Benth.
Eriogonum flavum Nutt.
Juncus tenuis Willd. var. congestus Engelm.
Spartina gracilis Trin.

The geysers are actively throwing up in jets at periodic intervals, steam and boilling water; the hot springs are either quiescent, or are bubbling without explosive eruption. They are found in four distinct areas in the Park; the geysers and the hot springs in the Upper, Lower and Norris Geyser Basin, hot springs only in the Mommoth Hot Spring Region. This division also accords with the predominating chemic content of the waters. In the Upper, Lower and Norris Geyser Basins, we have springs and geysers which are actively depositing silicious material (sinter); in the Mammoth Hot Spring Basin, springs which are forming calcareous deposits, called travertine[3]) (see plate XIII).

In the hot springs of the Yellowstone no plant life has been found at a temperature exceeding 185° F., some degrees below the boiling point of water, which, at the altitude of the park (7,000—8,500 feet) is 198° F. The most luxuriant growth of algae is found in water which has cooled down to a temperature of 104° F. to 125° F.; (= 40° C. to 52° C[3]) in such water we have the greatest display of color, because many green algae can live in water of that degree of heat. In the hottest waters (185° F. = 85,4° C.) only white filamentous bacteria are found, which gradually become of a sulphur-yellow color at 175° F. (80° C.).

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1) Tweedy, Frank: Notes on the Flora of Yellowstone Park. Bulletin Torrey Botanical Club XII: 24—26.

2) Tweedy, loc. cit. p. 21.

3) Harshberger, John W.: Vegetation of the Yellowstone hot Springs. American Journal of Pharmacy LXIX.; 625. Dec. 1897.

SETCHELL[1]) concludes after a study of the upper temperature limits of life that no living diatoms occur in strictly thermal waters and that the plants of hot springs belong to the Bacteriaceae and Cyanophyceae. The Cyanophyceae grow in water up to a temperature of 150°—158° F. (65°—68° C.); scantily at a temperature ranging between 168°—172° F. (75°—77° C.) while the Bacteriaceae endure highest temperatures and are abundant at 158°—160° F. (70°—71° C.) and in considerable quantity at 180° F. (82° C.), and at (192° F.) 89° C. Such plants live in silicious waters at a higher temperature than in calcareous waters, the limits being green algae 168°—172° F. (75°—77° C.) and chlorophylless plants at 192° F. (89° C.).

As the water cools down, other forms of vegetable life appear, give variety to the colorations and give beauty to the borders of the hot pools and overflow channels leading from them. The sequence of temperatures and colors is somewhat as follows: White 160° F.—185° F.; yellow, 145° F.—160°F.; red, 130° F.; green 110° F.—130° F.; green-orange-brown, 95° F. There are variations, however, in the sequence of these colors, owing to various environmental conditions. Thus, in the Black Sand Basin and Specimen Lake, the range of color is somewhat this: White, yellow, flesh pink, bright pink, yellowish-green, emerald. The prevailing tints are yellow at 185° F. (85° C.), green preponderating at 132°—150° F. (55°—65° C.) and prevailing green, 104°—122° F. (40°—50° C.).

Studying the growths at several temperatures, we find *Leptothrix laminosa* growing at 135° F.—185° F.; *Phormidium* at 165° F.; *Beggiatoa* at 150° F. —165° F., and *Spirulina* at a lower temperature. The leathery felt about the edges of hot springs is due to species of *Phormidium* the smallest of which is found in water as hot as 166° F. (75° C.). *Spirulina* grows with *Phormidium* and forms with it curious raised rims about such pools as Prismatic Spring. As the water grows cooler in the overflow streams species of *Anabaena* occur[2]).

Gloeocapsa, a blue-green alga, is found growing on the sides of geyser cones, where steam is escaping, forming there a delicate olive-green coloration. A kind of fibrous sinter is formed by the growth of the little alga, Calothrix gysophila, or the young form of Mastigonema thermale, the latter olive colored, and forming the sinter of the crater of the Excelsior Geyser[3]). A coarse sinter is due to a bright red species, Leptothrix, a finer variety to Leptothrix, (Hypheothrix) laminosa, ranging from white to flesh pink, yellow and red to green, as the water cools. Besides the above plants, which belong to the Bacteriaceae and the Cyanophyceae, speaking in a general way, we find that several mosses are active in the formation of sinter on the slopes below Hillside Spring. These springs issue from the rhyolite slopes beneath the cliffs of the Madison Plateau, and the waters, whose temperatures are 184° F.—198° F., contain both silica and lime in solution, which they deposit in their downward flow. This moss has been determined by CHARLES R. BARNES, of the University of Wisconsin, to be Hypnum aduncum, var. gracilescens.

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1) Science, new ser. XVII: 934. June 12, 1903.

2) DAVIS, B. M.: Vegetation of the hot Springs of the Yellowstone. Science. new ser. VI: 145.

3) WEED: loc. cit.

Besides the sinter and travertine formed by algae, which remove in the case of the carbonated waters, containing calcium bicarbonate, $Ca(HCO_3)_2$ in solution, the gaseous carbon dioxide, thus depositing calcium carbonate, $CaCO_3$, we have stalactites produced by the growth of several algae, Gloeocapsa violacea, Schizothrix calcicola, Synecococcus aeruginosus and Phormidium (Leptothrix) laminosum. An interesting account of the formation of these stalactites has been given to us by JOSEPHINE TILDEN, who visited the Yellowstone Park to study the thermal algae.

In the tepid waters of the overflow basins, for example Specimen Lake, which is produced by the water from Black Sand Pool, we find extensive diatomaceous beds formed by the growth of numerous diatoms. The water of these areas has encroached on the timber, killing the trees, which stand as bare poles from the treacherous marshes. It is known that these plants deposit silica, as a box, test, or frustule, and it is thus by the activity of the protoplasm that the silicious diatomaceous earths are formed. Samples of this material show the presence of Denticula valida, which forms the bulk of the material, Denticula elegans, Navicula major, N. viridis, Epithemia Argus and E. Hyndmannii, Cocconema cymbiforme, Achnanthes gibberula and Mastigloia *Smithii*.

## 4. Grassland and Rocks.

*Park Formation.* The open parks in the Yellowstone country are covered with grasses which form a conspicuous element of the vegetation. Such grasses as *Phleum alpinum*, *Sporobolus* (*Vilpa*) *asperifolius*, *Agrostis scabra*, *Muhlenbergia mexicana*, *Calamagrostis canadensis*, *C. confinis*, *Stipa comata*, *Agropyron divergens*, *A. caninum*, *Stipa viridula*, *Koeleria cristata*, *Melica bulbosa*, *Festuca ovina*, *Bromus breviaristatus* and such sedges as *Eriophorum polystachyum*, *Carex rigida*, *C. Jamesii*, *C. Douglasii*, *C. aquatilis*, *C. Raynoldsii*, *C. leporina*, *C. tenuirostris* are found.

On the elevated grassy slopes set in the uniform forest growth occur Caltha leptosepala, Oxytropis nana, Astragalus Kentrophyta, Erigeron ursinus, Aplopappus suffruticosus, Senecio amplectens. At lower elevations, the same character of country is set off with copses of Abies grandis and such plants as Ribes viscosissimum, Peucedanum leiocarpum, Ligusticum scopulorum, Lonicera caerulea, Aster conspicuus, A. integrifolius, Senecio triangularis, S. andinus, Hieracium Scouleri, Gaultheria myrsinites, Orthocarpus Parryi (= O. pallescens), Echinosperum deflexum, Spiranthes Romanzoffiana, Fritillaria pudica, Calochortus eurycarpus, and Botrychium simplex occur and give character to the vegetation[1].

Plants to reach these parks from below must make their way up narrow canyons or else over passes and this peculiar situation leads to a paucity of plants from lower altitudes and an abundance of peculiar mountain forms. Aquilegia coerulea is abundant in Colorado in many places. Willows, poplars and alders fringe the streams, such as Populus balsamifera, P. angustifolia, &c. Pentstemon secundiflorus occurs in such moist places as also Potentilla fruticosa[2].

Rocky Hills. The broken parts in the Uintah Mountains contain on the border, small groves of *Pinus Murrayana* in which *Astragalus alpinus*, *Pachystima myrsinites*, *Arctostaphylos uva-ursi*, *Juniperus communis* var. *alpina* occur. The open rough hilly parks according to PAMMEL[3]) contain *Potentilla*

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1) TWEEDY, FRANK: Flora of the Yellowstone National Park.

2) RAMALEY, FRANCIS: Remarks on the Distribution of Plants in Colorado, East of the Divide. Postelsia. 1901 p. 41.

3) PAMMEL, L. H.: Some ecological Notes on the Vegetation of the Uintah Mountains. Contributions Botanical Department Iowa State College of Agriculture and Mechanic Arts. No 22. Science X: 57—68.

*Hippiana, Eriogonum umbellatum, E. ovalifolium, Arenaria congesta, Castilleia miniata*, and as the chief constituent *Artemisia tridentata* and in scattered bunches *Bigelovia*. Open xerophytic parks exist between streams in these mountains where are found *Campanula rotundifolia, Cnicus Drummondii, Arenaria congesta, Potentilla Hippiana* and *Artemisia tridentata*.

Rock Outcrops. There is little or no vegetation where the outcrops of rock occur in the Flathead Valley. The undisintegrated rock has a covering of lichens of the foliaceous sort. With the accumulation of more soil such a fruticose lichen as Cladonia rangiferina var. sylvatica appears accompanied by Selaginella densa, Sedum Douglasii, Heuchera parvifolia. The rock crevices however filled with soil are favorable for the growth Prunus demissa, Amelanchier alnifolia, Juniperus nana (= J. sibirica), Campanula rotundifolia, Arctostaphylos uva-ursi. If the outcrop is near a large body of water Juniperus scopulorum is found and with it Pseudotsuga Douglasii and Pinus ponderosa[1]).

## 5. Alpine Formations.

These extend properly above timber-line which in the Park Mountains may be fixed approximately at an elevation between 11,000 and 12,000 feet (3350—3660 m). It is a rock desert and steppe belt. Mat-forming plants and deep-rooted perennials are common. In Colorado the alpine flora at 12,000 feet, or above, according to COCKERELL[2]) comprises 386 species, 48 of which extend to the old world. Boulder fields are practically destitute of vegetation except lichens. Sedges and grasses are numerous in species, but seldom form a dense sod, being mixed with various flowering herbs. Dwarf willows occur often forming a dense scrub over large areas, but there are no other woody plants. — None of the peaks are glaciated, although snow banks persist in protected places well through the summer months. The trees which reach timber-line in the Rocky Mountains are *Abies subalpina, Pinus albicaulis*, mountain hemlock *Tsuga Pattoniana, Pinus aristata, Pinus flexilis, Picea Engelmanni* (Uintah Mountains).

*Alpine meadow Formation.* The facies of this formation in Colorado[3]) is due to *Carex rupestris, Carex filifolia, Sieversia grandiflora, Festuca brachyphylla* var. *nana*.

Associated together as the principal species are Primula angustifolia, Androsace chamaejasme, Eritrichium arctioides, Saxifraga flagellaris, S. chrysantha, Dryas octopetala, Sibbaldia procumbens, Potentilla rubricaulis, Artemisia scopulorum, A. Pattersoni, Castilleia occidentalis, Polemonium confertum, Campanula uniflora, Trifolium nanum, Lloydia serotina. As secondary species exist Pedicularis Parryi, Carex festiva, Draba streptocarpa, D. aurea, Festuca ovina var. caespitosum. Later in the season the facies changes somewhat, then Deschampsia caespitosa var. alpina, Polygonum viviparum prevail with the following herbs; Phleum alpinum var. coryphocolum, Trisetum subspicatum, Gentiana tenella, Agoseris (Troximon) aurantiaca, Poa Grayana.

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1) WHITFORD: loc. cit. p. 216.

2) The Alpine Flora of Colorado. American Naturalist XL: 861—873; also COOPER, W. S.: Alpine Vegetation in the Vicinity of Long's Peak, Colorado: The Botanical Gazette XLV: 319—337.

3) CLEMENTS, FREDERIC E.: Formation and Succession Herbaria. University of Nebraska Studies IV, No. 4, Oct. 1904.

On Mount Lincoln, Colorado, in a grassy meadow kept wet by the melting snow grew Primula Parryi, P. angustifolia, Actinella (Rydbergia) grandiflora, A. (Tetraneuris) acaulis, Sedum Rhodiola (= R. rosea), S. rhodanthum, Geum (Sieversia) Rossii, Calandrinia pygmaea (Oreobroma Grayi), Saxifraga cernua, with white or cream colored flowers and numerous stolons, S. punctata with white petals and a tall naked scape.

The meadows of the Wind River range above 9000 feet are characterized by Saxifraga nivalis, Eritrichium (Omphalodes) aretioides, Polemonium confertum, Townsendia spathulata, T. scapigera, Bupleurum ranunculoides (= B. americanum), Llyodia serotina. Within the timbered recesses of these mountains are grassy meadows dotted with clumps of willows between which course clear mountain streams overhung with vegetation. In this variety of exposure, limited in every direction by irregular, rocky ridges, occurs a confused association of Draba alpina, Lupinus caespitosus, Hedysarum borealis (= H. americanum), Astragalus alpinus, Oxytropis campestris, Sedum stenopetalum, S. rhodanthum, Actinella (Rydbergia) grandiflora, Antennaria dioica, Senecio lugens, Kalmia glauca, Synthyris plantaginea, Mertensia paniculata, Gilia nudicaulis, Androsace septentrionalis[1], Primula Parryi, Gentiana humilis, Phacelia sericea[2]).

*Alpine Lakes and Bogs.* The alpine lakes of the Pike's Peak region exist between 3,110 m and 3,265 m altitudes and also below timber line. Marsh Lake is surrounded by a circumarea of *Sparganium angustifolium* on the shore side and an inner much interrupted circumarea of *Ranunculus* (*Batrachium*) *flaccidum*. Michigan Lake is completely overgrown with the same *Sparganium*. According to CLEMENTS the most important plants in these alpine lakes in the order of their importance are: *Sparganium* and *Potamogeton alpinus* with which are associated as of secondary importance *Utricularia vulgaris*, *Callitriche bifida* and *Isoetes lacustris* var. *paupercula*. In Isoetes Lake there is a rank growth of *Batrachium flaccidum* near the center of the lake. At Bald Mountain Lake mosses constitute the only macroscopic flora. The other types of alpine lakes, however, show, as well as the lakes above mentioned, a plankton consisting of algal species of *Spirogyra*, *Oedogonium*, *Mesocarpus*, *Volvox*, *Cosmarium*, *Zygnema*, *Coleochaete*, *Bulbochaete*, *Chara* and *Cladophora*[3]). — In the Rocky Mountains of northern Colorado the lakes of the subalpine and alpine districts are of the morainal type[4]). The lakes above timber line show no true circumareas, although birches and willows with grasses, sedges and such plants as species of *Elephantella*, *Pedicularis*, *Dodecatheon*, and *Clementsia* exist between the water edge and the coniferous forest behind.

Alpine Bog Formation. According to CLEMENTS this formation in Colorado consists early in the season of a facies, the elements of which are Carex scopulorum, C. melanocephala (= C. alpina), Caltha leptosepala associated with such species as Carex aurea, C. brunnescens, C. acutina, C. alpina, C. variabilis, and the following as secondary in importance: Juncus subtriflorus, Vaccinium myrtillus, Veronica alpina (= V. Wormskjoldii). Later the facies consists of Scirpus pauciflorus (= Eleocharis pauciflorus), Polytrichum gracile and principally of

1) The widely distributed arctic-alpine species, also European, printed in widened letters.

2) PARRY, C. C.: Botanical Observations in western Wyoming. American Naturalist VIII: 13.

3) SCHANTZ, H. L.: Biological Study of the Lakes of the Pikes Peak Region. Transactions American Microscopical Society XXVII: 75—97.

4) RAMALEY and ROBBINS: Science new series XXVII: 208.

the herbs: Antennaria nardina, Senecio crocatus, Carex capillaris, and as secondary species: Juncus triglumis, J. castaneus.

*Alpine Mat Formation.* The facies of this formation early in the season is *Paronychia pulvinata*, *Silene acaulis*, *Arenaria sajanensis*, *Erigeron pinnatisectus*, *Actinella* (*Tetraneuris*) *lanata* and the principal herbs associated with above in this formation are *Trifolium dasyphyllum*, *Carex petasata* (= *C. leporina*), *Zygadenus elegans*, *Polygonum bistortoides*, *Pentstemon Hallii*, *Agropyrum Scribneri*, *Sieversia turbinata* var. *nana*, *Potentilla minutifolia* with the following as secondary elements of the early season: *Saxifraga austromontana*, *Phacelia Lyallii*, *Festuca brevifolia* (= *F. brachyphylla*). Later in the season the presence of *Senecio taraxacoides*, *Potentilla fruticosa* var. *tenuifolia* changes the facies and the principal herbs at that time of the year are: *Macronema pygmaea*, *Trisetum subspicatum*, *Calamagrostis purpurascens* and associated with them are: *Sedum stenopetalum*, *Arenaria* (*Alsine*) *verna* var. *aequicaulis*. Only one fern occurs, viz: *Cryptogramma acrostichoides*. — Timber line is reached on Pikes Peak at approximately 11,500 feet (3500 m).

The plants characteristic of the treeless alpine belt are Senecio Fremontii, Artemisia scopulorum, Mertensia alpina, Eritrichium argenteum, Paronychia pulvinata, Silene acaulis, Claytonia megarrhiza, Primula Parryi, Salix reticulata (= S. saximontana) Saxifraga cernua, Gilia sp., Oxyria digyna, Chionophila Jamesii, Trifolium dasyphyllum, T. nanum, Dryas octopetala, Erigeron uniflorus, Solidago multiradiata, Saxifraga rhomboidea, S. Jamesii, Campanula uniflora, Pentstemon Hallii, Cymopterus (Oreoxis) alpinus, Caltha leptosepala (= C. rotundifolia). — High upon Mount Lincoln, Colorado at 14.000 feet (4270 m) where found the following plants of cespitose habit. Silene acaulis, Claytonia caroliniana, var. lanceolata, C. arctica var. megarrhiza, with its deep, purple tap root running deep into the rocks and its scape with white flowers, Trifolium longipes, T. nanum, T. dasyphyllum, T. Parryi, Eritrichium (Omphalodes) aretioides.

On the high alpine crest at the head of Stinking Water, overlooking to the west the Yellowstone basin and lake[1]) the flora displays the usual dwarf forms of high alpine summits, viz: Arabis Drummondii, Arabis canescens, Draba alpina, Smelowskia calycina, Arenaria arctica, Ivesia (Horkelia) Gordonii, Potentilla dissecta, Astragalus alpinus, A. Kentrophyta (= Homalobus montanus), Lupinus minimus, Sedum stenopetalum, Erigeron compositus, Senecio canus, Achillea millefolium, Phlox Douglasii, Mertensia alpina, Myosotis alpestris, Eriogonum ovalifolium.

The bare wind swept summit of Mount Holmes in the Yellowstone Park is characterized by the presence of Douglasia montana, Salix reticulata, Draba crassifolia, D. alpina, Smelowskia calycina, Arenaria Michauxii (= A. stricta), Silene acaulis, Saxifraga oppositifolia, Oxytropis Lamberti, Astragalus tegetarius var. implexus, Dryas octopetala, Sibbaldia procumbens, Antennaria alpina, Artemisia scopulorum, Erigeron uniflorus, E. radicatus[2]).

*Alpine Rockfield Formation.* According to CLEMENTS, the exposed rocky areas where boulders are found, or where the surface is bare and stony, are characterized early in the season by a facies of *Polemonium speciosum* (= *P. humile*), *Primula Parryi*, *Claytonia arctica* var. *megarrhiza*, *Boykinia Jamesii*,

1) PARRY, C. C.: Botanical Observations in western Wyoming. American Naturalist VIII: 107.

2) TWEEDY, FRANK: Notes on the Flora of Yellowstone Park. Bulletin Torrey Botanical Club XII: 25.

*Heuchera Hallii* and *Aquilegia saximontana*, *Synthyris plantaginea* var. *coryphocolus*, as of minor importance. The facies late in the growing season, which is short on these high mountains, consists of *Senecio carthamoides*, *Oxyria digyna*, *Selaginella densa*.

Elsewhere in the debris of broken granite blocks grow *Trifolium nanum*, *Papaver nudicaule*, *Saxifraga serpyllifolia*, *Gentiana frigida*, *Pedicularis sudetica* and other plants [1]).

The alpine flora of the Yellowstone Park is comprised of the following list according to TWEEDY [2]). Those marked * are arctic.

*Poa alpina L.
*Phleum alpinum L.
*Trisetum subspicatum Beauv.
*Festuca ovina L. var. brevifolia Wats.
*Carex atrata L.
* » alpina Swartz.
* » rigida Good.
» concinna R. Br.
» scirpoidea Michx.
Juncus Parryi Engelm.
» Drummondii E. Meyer.
*Luzula spicata Desv.
*Lloydia serotina Sweet.
Habenaria obtusata Richards.
*Salix reticulata L.
» arctica Pall. var. petraea Anders.
*Polygonum viviparum L.
*Oxyria digyna Camptd.
*Draba alpina L.
» crassifolia Graham.
» aurea Vahl.
*Smelowskia calycina Desv.
*Thlaspi alpestre L.
*Silene acaulis L. Wats.
*Arenaria verna L. var. hirta
*Arenaria stricta Michx.
Sagina Linnaei Presl (= S. saginoides L.).
Calandrinia pygmaea Gray (= Oreobroma Grayi Britt.).
*Dryas octopetala L.
Ivesia (Horkelia Gordonii Hook.
*Sibbaldia procumbens L.
Trifolium Parryi A. Gray.
*Astragalus alpinus L.
Saxifraga Jamesii Torr. (= Telesonix Jamesii Torr.).
*Saxifraga oppositifolia L.
* » caespitosa L.
* » rivularis L.
* » nivalis L.
* » punctata L.
Sedum rhodanthum A. Gray.
*Epilobium latifolium L.
*Eritrichium aretioides DC. (= Omphalodes nana Gray var. aretioides Gray).
Mertensia alpina Torr.
*Veronica alpina (= V. Wormskjoldii R. & S.).
*Castilleia pallida Kunth. var. septentrionalis Gray (= C. acuminata Pursh).
Pentstemon Menziesii Hook.
Pedicularis Parryi A. Gray.
» scopulorum A. Gray.
» groenlandica Retz.
Bryanthus (Phyllodoce) empetriformis Smith.
Douglasia montana A. Gray.
Polemonium confertum A. Gray.
* » humile Willd. var. pulchellum Gray.
Aplopappus (Pyrrocoma) Lyallii A. Gray.
*Erigeron uniflorus L.
» ursinus Eaton.
» radicatus Hook.
*Antennaria alpina Gaertn.
Artemisia scopulorum A. Gray.
Hulsea nana A. Gray.
Senecio Fremontii Torr. & Gray.
*Taraxacum officinale Weber. var. scopulorum A. Gray.

The Big Horn Mountains which begin near the middle of the northern boundary of Wyoming run in a northwest and southeast direction one third across that state. The flora of this region does not materially differ from that of the adjacent Rocky Mountain range to the west in Wyoming and northwest in Montana. The alpine plants found at an altitude of 9,000 to 11,300 feet are [3]):

Carex atrata L.
» capitata L.
Carex nova Bailey.
» scirpoidea Michx.
Dryas octopetala L.
Artemisia scopulorum A. Gray.

1) PARRY, C. C.: Review of work in Botanische Zeitung, 1863: 173, 181, out of American Journal Science and Arts. XXXIII (1862).

2) TWEEDY, FRANK: Flora of the Yellowstone National Park. 1886. 16—18.

3) ROSE, J. N.: Plants from the Big Horn Mountains of Wyoming. Contributions U. S. National Herbarium II: 567—568.

Erigeron lanatus Hook.
Geum (Sieversia) Rossii R. Br.
Kalmia glauca var. microphylla Hook. (= K. microphylla Hook.).
Mertensia alpina Torr.
Myosotis sylvatica var. alpestris Koch (=M. alpestris Schmidt).
Eritrichium (Omphalodes) Howardi A. Gr.
Orthocarpus pilosus Wats. (= Castilleja pilosa Wats.).
Pedicularis Parryi A. Gray.
Primula Parryi A. Gray.
Anemone narcissiflora L.
Ranunculus Eschscholtzii Schlecht.
Calandrinia pygmaea A. Gray (= Oreobroma Grayi Britt.).
Silene acaulis L.
Salix chlorophylla Anders.
» glauca L. var. villosa.

The alpine and subalpine floras of the Western slope of Rocky Mountains in southwestern Colorado are at this southern latitude almost the same as those of northern Colorado. Pachystima myrsinites, Erythronium grandiflorum are common. Aquilegia canadensis takes the place of A. caerulea found with such northern ones as Calypso borealis, Listera cordata, Nephrodium (Aspidium, filix-mas.

## c) Black Hills Area.

The flora of the Black Hills of South Dakota is varied. This is due to their phytogeographic location (see page 107) which is midway between the coniferous forest around the Great Lakes, the deciduous forest vegetation of the east and the Rocky Mountain vegetation, while in addition they are surrounded by the vegetation of the prairies and the great plains (see colored map). It consists of plants from the east (see page 240), from the Saskatchewan region, from the prairies and table-lands west of the Missouri River, from the Rocky Mountains and from the region west thereof. In the foothills and the lower part of the Black Hills the flora is essentially the same as the plains in the midst of which these mountains are found. The more elevated portions have a vegetation of more northern origin. Some plants belong to the Rocky Mountains; among them two trees *Pinus ponderosa* var. *scopulorum* and *Betula occidentalis*, the rest of the plants are eastern or transcontinental. The flora of the lower parts of the district resembles, therefore, more the flora of the Interlacustrine Area than that of the Rocky Mountain Region. The foothills and surrounding plains may be omitted from consideration, because the vegetation is essentially that peculiar to the high dry plains of Nebraska, Wyoming and neighboring States. The really mountainous parts of the Black Hills which are related topographically and in part floristically to the Rocky Mountains is the Harney Range. The principal tree is the Rocky Mountain yellow pine *Pinus ponderosa* var. *scopulorum*, which is the only tree that makes a forest. As this tree forms the principal facies, the district has been placed in the classification as a part of the Rocky Mountain Region. On the north side of the mountains is the northern white spruce *Picea alba* (= *P. canadensis*). It must have come into the district when the climate was much colder than now.

Of the deciduous trees there are: Betula papyrifera, B. occidentalis, Populus tremuloides, Salix Bebbiana (= S. rostrata), S. discolor, S. cordata, while down along Squaw Creek occur Quercus macrocarpa, Ulmus americana. The shrubby plants are Amelanchier alnifolia, Cornus stolonifera, Corylus rostrata, Neillia opulifolia, Ribes setosum, Ribes oxyacanthoides, R. cereum, R. lacustre, Shepherdia canadensis. The following Rocky Mountain plants occur in the

Harney Mountains; Actaea spicata var. arguta, Aster sibiricus (= A. Richardsonii), Arnica alpina, Arenaria verna var. hirta, Dodecatheon pauciflorum, Epilobium paniculatum, Epilobium Drummondii, Helianthemum majus, Myosotis sylvatica, Pyrola rotundifolia var. bracteata, Leucocrinum montanum, Synthyris (Wulfenia) rubra, Viola canina var. adunca (= V. adunca) while, as northeastern plants occur Fragaria virginiana, Hypericum canadense, Lobelia spicata var. hirtella, Stachys aspera, Halenia (Tetragonanthus) deflexa, Viola blanda, Viola palustris[1]. — The damp atmosphere of the Harney range permits the following ferns to grow; Asplenium trichomanes, A. filix-foemina, A. septentrionale, Botrychium matricariaefolium (?), Nephrodium filix-mas and dryopteris, Cystopteris fragilis, Pteris aquilina, Polypodium vulgare, Polypodium vulgare var. rotundatum, Selaginella rupestris, Woodsia oregana, W. scopulina.

The limestone table-land in the Black Hills is covered with *Pinus ponderosa* var. *scopulorum* and *Populus tremuloides* and such shrubs as *Ribes cereum*, *Shepherdia canadensis*, *Elaeagnus argentea*, *Ceanothus Fendleri*, *Salix Bebbiana*, *S. discolor*, *Juniperus communis*. The northern Hills have a woody flora in which the pine predominates.

The following shrubs and lianes occur here in addition to those above mentioned: Ceanothus ovatus, Potentilla fruticosa, Ampelopsis (Parthenocissus) quinquefolia, Lonicera hirsuta var. glaucescens, Viburnum lentago, Vitis vulpina. Here in the canyons grow many eastern plants viz: Echinospermum virginianum, E. deflexum var. americana, Lysimachia thyrsiflora, Polygala senega var. latifolia, Lathyrus ochroleucus, Halenia deflexa, Viola scabriuscula, and the following western species: Arnica alpina, A. cordifolia, Calochortus Gunnisoni, Claytonia perfoliata var. amplectens, Epilobium Drummondii, Frasera speciosa, Heuchera parvifolia, Hieracium Fendleri, Lesquerella spathulata, Lupinus parviflorus, Potentilla glandulosa, P. humifusa, Osmorrhiza (Washingtonia) nuda, Mertensia sibirica, Mimulus luteus (M. Langsdorfi), Thalictrum occidentale, T. venulosum.

## 3. Great Basin Region.

Between the towering rim of the Sierra Nevada Mountains on the west, which prevents the moist winds of the Pacific Ocean from crossing, and a lofty eastern rim in part represented by the Wasatch range, that bars out the Gulf winds, lies a great area without any drainage outlet to either ocean, known as the Great Basin. The low south rim permits the hot dry south winds to sweep over the basin. Most of the valleys in this country are utter deserts. There is absolutely no water in them from one end of the year to the other. Small rivulets formed by melting snow run part way down the mountain slopes, but they sink out of sight before reaching the plain. The flora in such a region is, therefore, of a most pronounced arid type and desert shrubs and perennial herbs represent the chief components of the natural vegetation[2]).

### A. Oregon District.

The eastern portion of the states of Washington and Oregon is a great arid plain centering about the Columbia River and this plain owes its aridity

1) RYDBERG, P. A.: Flora of the Black Hills of South Dakota. Contributions U.S. National Herbarium III. No. 8: 463—478; BESSEY, C. E.: Ferns of the Black Hills. American Naturalist XXVI: 252; WILLIAMS, T. A.: Notes on the Flora of western South Dakota do XXVI: 253.

2) Cf. LIVINGSTON, B. E.: The Relation of desert Plants to Soil-Moisture and Evaporation. Publ. 50 Carnegie Institution 1906.

to the fact that the moisture-laden winds of the Pacific are cut off by the Cascade range of mountains. The eastern limit of this plain is the western base of the Bitterroot Mountains toward the north, while the Rocky Mountains form the eastern boundary in the south.

Thus a great wedge-shaped area is formed, its base continuous with the deserts of Nevada and its apex in the north surrounded by the forest which connects the northern end of the Bitterroot Mountains with the northern end of the Cascades. The southern boundary of this district is marked by STEIN'S Mountains, Goose Lake and Upper Klamath Lake in extreme southern Oregon. The absence of *Larrea mexicana* (the creosote bush), various Cactaceae delimits these deserts from those of southern Arizona.

*Sage brush Formation.* The vegetation of this district consists principally of sage brush *Artemisia tridentata*, which covers the country away from the streams with a gray mantle and constitutes probably nine tenths of the vegetation. Here there is never a sod except in favorable localities along streams where the sedges and native clovers abound. The grasses of many species are all bunch grasses and the clumps are invariably separated by intervals of a few inches to several feet. The entire absence of buffalo grass *Buchloë dactyloides* and grama grass *Bouteloua oligostachya* is noteworthy. There are many annual plants and growing with them are tuberous rooted perennials which have stored up during the preceding year's growth a large amount of reserve food.

In the lower portions of all the basin, as well, as in poorly drained areas along the river bottoms, are situated intensely alkaline areas which support no vegetation whatever and are known locally as "sleek deserts".

A few trees occur in this desert. *Pinus albicaulis* makes a scanty growth at highest elevations on Pine Forest range. STEIN's Mountains have no pines, but *Juniperus virginiana* is quite abundant. *Pinus ponderosa* var. *scopulorum*, the bull pine, occurs in the spurs of the Blue Mountains. Aside from the pines and juniper the only trees of the district are *Populus tremuloides*, *P. trichocarpa*. Among the shrubby plants which form dense thickets, often over areas of considerable extent, may be mentioned: *Cercocarpus ledifolius*, *Amelanchier alnifolia*, *Ceanothus velutinus*, *Holodiscus dumosus*, *Symphoricarpos oreophilus*, *Potentilla fruticosa*, *Prunus emarginata*, *P. demissa* (Chaparral Formation). Along the moister gulches one always finds a profuse growth of willows which are also sometimes found forming thickets on high, moist, shady slopes. Extensive growth of alder are also found in the same localities [1]).

The yellow pine belt in eastern Washington lies between the altitudes 1,800 and 3,300 feet (550 and 1000 meters). In places Pinus ponderosa descends nearly to sea level, as along the Columbia River, but it shows a marked predilection for soils of granitic origin. Where pure the forests of this tree are open in character and marked by a relatively small amount of forest litter. There is a scattered growth of various shrubs such as Physocarpus

1) See GRIFFITHS, DAVID: see Bibliography p. 76.

(Opulaster, pauciflorus, Ceanothus sanguineus, Rosa gymnocarpa. At a higher altitude, the undershrub is a huckleberry Vaccinium macrophyllum. These pine forests are seldom pure except at low elevations. In moister situations at higher altitude the red fir Pseudotsuga Douglasii becomes associated with the pine, until according to PIPER, with increasing altitude the forest becomes similar to that on the mountains of the humid Pacific side of Washington and Oregon.

The grasses of the upland thickets in the Blue Mountains of Oregon are *Poa pratensis*, *Trisetum subspicatum*, *Danthonia californica*, *Melica subulata*, *Elymus glaucus*, *Carex Geyeri*.

The principal facies of the Sage Formation: consists of the scattered clumps of *Artemisia tridentata*, associated with *A. arbuscula*, *A. cana* (in the mountains). *A. tridentata* is the black sage of the mesas and foot hills and takes the place of creosote bush *Larrea mexicana* and the Cactaceae of the deserts to the southward. With it is sometimes associated *Artemisia spinescens* while *Atriplex confertifolia*, *A. Nuttallii*, *Grayia spinosa*, *Eurotia lanata* are also elements in the sage formation.

The rolling hills in the Okanogan country are covered with a luxuriant growth of Festuca ovina, Agropyrum spicatum (= A. divergens), Poa Wheeleri, Poa Sandbergii, while elsewhere occur Wyethia amplexicaulis, Balsamorrhiza sagittata. B. Careyana, Bigelovia (Chrysothamnus) graveolens associated with Agropyrum spicatum and in places forming pure associations. Artemisia rigida also occurs in pure associations. — Still another association is composed of Artemisia rigida, A. arbuscula, Eriogonum dichotomum, E. sphaerocephalum, E. thymoides, Tetradymia canescens, Audibertia incana and Gilia pungens. The herbaceous vegetation consists of Gayophytum ramosissimum, Lygodesmia juncea, Agropyrum spicatum, Stipa Thurberiana, Festuca microstachya, Poa Sandbergii.

*Bunch grass Formation.* The bunch grass prairies constitute a strip of varying width lying between the sage brush formation and the yellow pine groves above. The soil is a black, clay loam, free from grit. These prairies are treeless and excepting along streams and by springs or on north hillsides, shrubs are rarely seen according to PIPER [1]). Of the herbaceous vegetation the bunch grass *Agropyrum spicatum* and June grass (*Poa Sandbergii*) are abundant together with *Lupinus ornatus*, *L. sericeus*, *L. Wyethii*, *Balsamorrhiza sagittata*, *Helianthella Douglasii*, *Gaillardia aristata*, *Geranium incisum*, *Leptotaenia multifida* and in moister places *Iris missouriensis*, *Wyethia amplexicaulis.*

The grasses in the Blue Mountains of Oregon are in the open places Poa nevadensis, Poa Wheeleri, P. Sandbergii, P. Buckleyana (P. tenuifolia), Festuca ovina, Agropyrum spicatum (= A. divergens), Koeleria cristata, Bromus marginatus, Elymus (Sitanion) longifolium, Elymus condensatus, Deschampsia caespitosa, Stipa viridula with Trifolium plumosum on the bare rocky slopes of the open country.

*Camass Meadow Formation.* This formation is situated in depressed areas more moist than the upland country. Here grow in the greatest profusion various grasses, interspersed with brillinatly colored flowers, such as *Camassia esculenta.*

Such a mountain meadow contains Poa Sandbergii, Agropyrum spicatum, Festuca ovina, Poa Wheeleri, Poa nevadensis. Koeleria cristata along with Achillea millefolium, Wyethia amplexicaulis, Arnica alpina, Erigeron aphanactus, Gaillardia aristata, Balsamorrhiza incana, Lupinus sulphureus, Clarkia pulchella, Navarretia Breweri, Gilia aggregata, Eriogonum heracloides, Geum trifolium, Pentstemon attenuatus, Deschampsia calycina, Polygonum Douglasii, Peucedanum leptocarpum, Calochortus Nuttallii and Sedum Douglasii. — Along Quinn River, the meadows show a rich growth of characteristic grasses and sedges.

*Greasewood Formation.* As one descends from the open plains into the valley bottoms the soil becomes alkaline and the vegetation changes, the sage brush *Artemisia tridentata* etc. being replaced by the greasewood *Sarcobatus vermiculatus* with *Distichlis spicata*, *Atriplex hastata*, *Bigelovia* (*Chrysothamnus*) *graveolens*, *Suaeda depressa* var. *erecta*, and *diffusa*, iodine weed *Spirostachys occidentalis*, *Sporobolus airoides*.

Stream Bank Formation. Along the streams and by springs willows of several species grow together with Crataegus brevispina (= C. Douglasii). Populus tremuloides, P. trichocarpa which form groves. The common undershrubs are Symphoricarpos racemosa, Rosa Nutkana, R. pisocarpa, Ribes inerme and R. irriguum. Occasionally the birch (Betula microphylla) is the most abundant shrub. The herbaceous plants found here are Castilleja miniata, Clematis hirsutissima (= C. Douglasii), Heracleum lanatum, Lupinus leucophyllus, Sidalcea oregana, Solidago serotina, Urtica Lyallii, U. holosericea, Valeriana ceratophylla.

## B. Nevada District.

The proper flora of the Great Basin occupies the states of Nevada and Utah parts of the states of Idaho and California north of the eastward flowing portion of the Colorado River. A large area of this district lying at elevations up to 5000 feet includes numerous valleys and widely extended plains with no outlet for the drainage. Into these the streams from the mountains flow and terminate in lakes at the lowermost part of the basin formed, or spread out in great flats or playas in such a manner that the waters disappear in the ground, forming what are known as sinks. The soil of the basin in many places, becomes highly charged with salts and supports a flora in which the predominant forms consist of perennial compositous shrubs of which the genus Artemisia furnishes three or four species known locally as sage-brush greasewood and desert sage.

No portion of this district, however desert, is destitute entirely of some vegetation, even in the driest season, excepting only the alkali flats, which are usually of quite limited extent. To the absence of trees outside of the mountains of the basin, there seems to be a single exception in the valley of the Truckee River, where *Populus monilifera* (= *P. deltoides*) and *P. trichocarpa* grow in considerable numbers in the river bottom. Ascending the mountain ranges for example Table Mountain 11,200 feet[1]), the botanist finds seven species of trees, viz: *Juniperus virginiana*, *Populus tremuloides*, *Pinus Bal-*

1) SARGENT, C. S.: The Forests of central Nevada. American Journal Science and Arts. Third ser. XVII (1879): 417—426.

*fouriana, P. flexilis, P. monophylla, Juniperus californica* var. *utahensis, Cercocarpus ledifolius.*

Juniperus californica var. utahensis in places associated with Streptanthus cordatus, Pentstemon puniceus, Phlox canescens, Berberis Fremontii, is the most common tree descending into valleys where at an elevation of 5,000 feet, it is often abundant, but less so on mountain sides over which it spreads up to 8,000 feet elevation. — Growing with this juniper above 6,000 feet elevation and extending higher up the mountains is Pinus monophylla. Pinus Balfouriana occurs on Prospect Mountain near Eureka at an elevation of 7,500 feet, while Pinus flexilis grows on Monitor Range from 8,000 feet up to 10,000 feet elevation, associated with Populus tremuloides on the banks of the mountain streams. — Cercocarpus ledifolius is common at 6,000 to 8,000 feet elevation and next to the juniper and Pinus monophylla is the most abundant of the trees of central Nevada. In the Washoe Mountains in common with the rest of the Sierras, there is a heavy growth of several conifers of which Pinus ponderosa extends down to the very base or even on to the valley slopes. Some of the high western canyons show a dense growth of Picea Engelmanni.

The shrubby or perennial vegetation consists of the omnipresent sagebrush Artemisia tridentata mingled in the less alkaline and drier portions of the valleys with Atriplex (Obione) confertifolia, A. (O.) canescens, A. Nuttallii, Audibertia (Ramona) incana, Sphaerostigma tortuosa, Tricardia Watsoni, Stipa comata, Juniperus californica var. utahensis, Pinus monophylla (the last seven extending up to 6000 feet out of the Truckee Valley), Grayia spinosa (= G. polygaloides), Artemisia spinescens, Eurotia lanata and Kochia prostrata, while Tetradymia canescens also occurs with the sage brush or with Artemisia trifida when that species replaces A. tridentata, Purshia tridentata associated with Ribes leptanthum; Prunus Andersoni is widely distributed above the base of the mountains.

The following most important genera of plants are found between the shrubs: Astragalus, Oenothera, Gilia, Phacelia, Emmenanthe, Nama (Conanthus), Eriogonum, Oxytheca, Chorizanthe, Tetradymia, Senecio, Stephanomeria, Glyptopleura, Lygodesmia, Malacothrix, Troximon[1].

For miles and miles the adobe plains in southwest Colorado are covered with *Artemisia tridentata*, with *Sarcobatus vermiculatus*, *Bigelovia graveolens*, *Atriplex canescens* common in scattered spots. Early in June the hills and mesas seem suddenly to burst into bloom, *Peraphyllum ramosissimum* is one of the earliest. *Fendlera rupicola* towers above every other shrub with white flowers. *Amelanchier alnifolia* is also in bloom at this season. *Purshia tridentata* and *Cercocarpus parvifolius* are common. *Quercus undulata* has put forth its early leaves. *Philadelphus microphyllus* is found on rocky hill and abrupt canyon sides.

The spring flowering herbs April 5th to June 1st as found in southern Utah, according to PARRY, consist at first of evanescent annuals, such as Phacelia Fremontii, P. crassifolia, P. micrantha, P. rotundifolia, followed by Gilia inconspicua, G. leptomeria, G. demissa, G. Bigelovii, G. floccosa, G. polycladon, G. setosissima. Among other interesting dwarf forms characterizing the early spring flora may be noted: Thysanocarpus curvipes, Malvastrum exile, Lupinus Sileri (= L. Kingii), Eriophyllum Wallacei, E. lanosum, Syntrichopappus Fremontii, Layia glandulosa, Styloclyne micropoides, Nemocladus ramosissimus, Nama demissa and Pterostegia drymarioides. As an early bulbous plant, Androstephium breviflorum grows on gravelly hills succeeded by Brodiaea (Milla) capitata. Early in May, Calochortus flexuosus is conspicuous on hillsides. After the late spring frosts, Oenothera albicaulis, Oe. Parryi, Dalea Johnsoni, Coleogyne ramosissima, Aster tortifolius, Audibertia incana, Lepidium Fremontii, Hymenoclea salsola, Franseria dumosa,

1) EASTWOOD, A.: The common Shrubs of southwest Colorado, Zoe. II: 102—104.

Salizaria mexicana. Opuntia rutila, Cereus Engelmanni, Mammillaria phellosperma, Opuntia echinocarpa appear in flower. The large class of compositous, chenopodiaceous and perennial Eriogoneae come forward in the latter part of May[1].

*River Bottom and Meadow-Formation.* The water courses are marked by the presence of *Salix longifolia*, *S. cordata*, *Rosa blanda*, *Shepherdia argentea Prunus demissa* and *Ribes aureum* with *Populus tremuloides* on the stream banks in the upper canyons.

On the banks of streams in the lower canyons are Ribes irriguum, Sambucus glauca, Cornus pubescens (= C. occidentalis) or more rarely Crataegus rivularis, Alnus incana, while on the rich moist hillsides are Wyethia amplexicaulis, Lophanthus urticaefolius, Geranium Richardsonii. The banks of the Truckee River, as it runs through Truckee Valley, are covered with a dense growth of Populus balsamifera, P. trichocarpa, Salix argophylla, S. lasiolepis, S. padophylla and Alnus rhombifolia, according to KENNEDY[2]. Populus tremuloides occupies large areas in the upper part of the river while in the more desert country beyond the Virginia Mountains, Populus Fremontii is the common tree. Along the banks grow Allium acuminatum, Artemisia aromatica, Cicuta vagans, Mimulus Langsdorfii, Prunus demissa, Rosa Woodsii and Ribes aureum. Above the valley grow Acer glabrum, Alnus tenuifolia, Amelanchier Cusickii, Ribes cereum.

Along the river bottoms in southwest Colorado grow Crataegus coccinea, Salix lasiandra, S. cordata var. Mackenziana. Occasionally clumps of Rhamnus californica, also occur with Rhus aromatica (= R. canadensis), Shepherdia argentea, Prunus demissa, Ribes aureum, Berberis Fendleri, while Pachystima myrsinites carpets the ground under the taller shrubs. Ceanothus Fendleri is common in open spots on rocky slopes. C. ovatus also occurs. In the basin of the Green River, an extension of the arid Great Basin into the mountains, are groves of Populus angustifolia beneath which trees grow Glycyrrhiza lepidota, Symphoricarpos racemosus, Rosa Fendleri while Salix longifolia, S. amgydaloides, Pirus sambucifolia, Rhus canadensis var. trilobata, Amelanchier alnifolia also are found. — The marshes and margins of the lakes may be green with Scirpus maritimus, Juncus balticus, Equisetum hyemale, Sporobolus (Vilfa) depauperata, Agropyrum repens.

The swamps in the Truckee Valley which are characterized by a dense growth of Typha latifolia, Sagittaria latifolia, Sparganium simplex intergrade with the meadows where are found, according to the soil and the amount of water, Carex ampullacea, C. aquatilis, C. lanuginosa, Eleocharis arenicola, Juncus, Scirpus and Trifolium spinulosum.

The following plants are to be classed as aquatic and meadow species[3]: Nasturtium (Roripa) lyratum, Selinum Kingii, Scirpus nevadensis, Carex Watsoni, Tillaea angustifolia, Iris Tolmieana (= I. missouriensis), Carex vesicaria, C. aemathorhyncha (= C. filiformis), Gentiana affinis, Epipactis gigantea, Zygadenus Nuttallii, Deschampsia danthonioides, Valeriana edulis, Aster simplex (= A. paniculatus), Gratiola virginiana. — Typha latifolia, Potamogeton natans, P. pectinatus, Alisma plantago, Sagittaria variabilis (= S. latifolia), Eleocharis acicularis, E. palustris, Elatine americana, Panicum crus-galli, Ceratophyllum demersum, Schollera graminea, Sparganium eurycarpum &c.

*Desert Sinks Formation*: The plants which are confined to alkaline spots in the desert or to desert sinks are *Spirostachys occidentalis*, *Sarcobatus vermiculatus* (widely distributed) associated with *Salicornia herbacea*, *Suaeda depressa* var. *fruticosa*, *Distichlis spicata* and *Spartina gracilis* which together form the characteristic vegetation.

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1) PARRY, C. C.: Bot. observ. in southern Utah in 1874. See Bibliography.

2) KENNEDY, P. B.: Botanical Features around Reno. Muhlenbergia III: 17—32.

3) WATSON: loc. cit. p. XXX.

The Black Rock Desert in northwestern Nevada is a "sleek desert", that is, it is barren of vegetation due to the excessive alkalinity of the soil. The first plants in the edge of the desert are iodine weed *Spirostachys occidentalis*, *Suaeda* (*Dondia*) *depressa* var. *erecta*, followed by *Distichlis spicata*, *Sarcobatus vermiculatus*, *Atriplex Torreyi* and *Mimulus Bigelovii*[1]).

*Mesa Formation:* On the mesas which are broad, flat, table-lands bounded at least on one side by a steep cliff rising from lower land, are scattering growths of shrubs such as: *Atriplex confertifolia*, *Artemisia spinescens*, *Tetradymia spinosa*, *Kochia americana*, *Grayia polygaloides*, *Aplopappus viscidiflorus*, *Eurotia lanata*. The mesa plants extend up the side of buttes for a considerable distance and *Kochia*, *Grayia*, *Eurotia* with *Tetradymia canescens* extend to the very top, where there are also found *Eriogonum species*, *Gilia pungens*, *Galium multiflorum* and *Lygodesmia spinosa*. On the sandy knolls of the mesas grows *Oryzopsis cuspidata*.

## Subalpine and Alpine Formations.

The constituent plants of the subalpine formations in the higher Sierras of the Great Basin are[2]) the following:

*Phleum alpinum.
*Carex rigida.
*Luzula (Juncoides) spicata.
*Juncus Parryi.
*Salix glauca.
*Polygonum bistorta
(= P. bistortoides).
P. coarctatum
(= P. spergulariaeforme).
*Eriogonum heracloides.
*Stellaria umbellata
(= Alsine baicalensis).
Ranunculus digitatus.
» nivalis var.
*Anemone multifida.
Sedum debile.
*Parnassia fimbriata.
*Saxifraga nivalis.
*Potentilla fruticosa.
Astragalus Robbensii.
» Hookerianus.
*Viola Nuttallii.
Epilobium obcordatum.
» alpinum.
*Gayophytum racemosum.
Ledum glandulosum.
Hydrophyllum capitatum.
Veronica alpina
(= V. Wormskjoldii).
Pedicularis (Elephantella)
groenlandica.
Aster pulchellus.
Erigeron asperugineus.
» Breweri.
Microseris nutans.
Artemisia arbuscula.
Arnica longifolia.
* » mollis.
* » cordifolia.
Senecio lugens.
*Achillea millefolium and
*Antennaria dioica.

The alpine region of the Nevada District is characterized by the presence of the following plants:

*Agrostis canina.
*Elymus sitanion
(= Sitanion elymoides).
*Trisetum subspicatum.
*Poa andina.
* » alpina.
*Carex atrata.
*Carex leporina.
» affinis (= C. obtusata).
*Lloydia serotina.
*Salix reticulata.
*Polygonum viviparum.
Eriogonum umbellatum.
» microthecum.
*Oxyria digyna.
*Silene acaulis.
*Arenaria arctica.
*Thalictrum alpinum.
*Caltha leptosepala.
*Draba nemorosa.
» stellata.

1) GRIFFITHS, DAVID: Forage conditions and Problems in eastern Washington, eastern Oregon. Bull. 38 Bur. Pl. Ind. 1903.

2) Species marked by an asterisk are present in other parts of Pacific N. America in the same formations and region.

*Smelowskia calycina.
*Thlaspi alpestre.
*Arabis Drummondii.
*Sedum Rhodiola.
Heuchera cylindrica.
*Saxifraga adscendens.
* » punctata.
*Geum Rossii.
*Potentilla dissecta.
Astragalus platytropis.
» aboriginorum.
Astragalus tegetarius.
» calycosus.
*Oxytropis campestris.
*Vaccinium caespitosum.
*Kalmia glauca.
*Pirola rotundifolia.
*Androsace septentrionale.
*Primula Parryi.
*Swertia perennis.
*Gentiana Parryi.
*Phlox caespitosa.
*Polemonium confertum.
*Antennaria alpina.
» carpathica.
*Erigeron compositus.
* » salsuginosus.
*Solidago virgaurea.
*Aster glacialis.
*Senecio amplectens.
» canus.
Chaenactis Douglasii [1]).

## C. Arizona- New Mexico District.

This district is characterized by the inclusion of such deserts, as the Painted Desert in northern Arizona, the Tularosa Desert in New Mexico and others stretching eastward to join the plains of western Texas and southward into the deserts of Chihuahua in Mexico.

This district lies southeast of the grand Canyon of the Colorado River. It embraces several mountain ranges which may be said on the higher summits to have a typic Rocky Mountain flora, which for purposes of convenience will be treated in connection with the consideration of the flora of the New Mexico-Arizona District.

Looking from a mountain top the traveller is impressed with the wonderful diversification of the desert landscape. Here he sees a vast flat of alkali: there an area of vulcanism where the lava has overflowed square miles of country. Elsewhere are arid hillsides and isolated table-lands, or mesas glowing with every conceivable shade of color. While in the distance rise mountain peaks that are during a large part of the year snow-copped. Elsewhere sand dunes are seen with characteristic wet dune bottoms, while progress across the country is blocked by deep canyons. The physiognomy of the vegetation impresses the botanist as much as the physiography for low mesquite trees abound with low thorny shrubs, yucca-like plants dotted over the arid plains, while the oak and piñon belts of the lower mountain slopes suggest a shrub steppe or a Mediterranean oak or laurineous forest where sclerophyllous trees are the prevailing type. —

The plants are modified structurally and seasonally to a desert climate. Their root systems are either deeply placed (*Prosopis juliflora*), or superficially placed and strongly branched (*Cereus giganteus*); their leaves are reduced in size; they have water-storing stems; their leaves are leathery or succulent with thick cuticle, sunken stomata and other protective devices, while their rapidity of development after showers of rain is astonishing. We have as a result of this two kinds of desert plants existing side by side, viz., typic desert xerophytes and desert mesophytes which develop during the

short speels of rainy weather. Such are the winter perennials (December—March) with rootstocks and bulbs which develop new shoots and form leaves and flowers under the influence of the rising temperature and moisture and the winter annuals the seeds of which germinate in the wet period and soon pass away. The spinose and succulent forms of the dry fore-summer (April—June), such as cacti, yuccas, woody herbs, shrubs and trees, flower under the influence of the advancing temperature on parts which have stored water earlier in the season. The short humid mid-summer follows with a second burst of bloom of summer annuals and perennials followed by the dry after-summer which sees the ripening of fruits and seeds [1]. A numeric statement of the proportion of the various kinds of desert plants is reserved for treatment in a later section under "Colorado Desert Vegetation".

### 1. The Desert plains, Mesas, Dunes and Gravel Hills.

*Desert Plain Formation.* The Tularosa Desert may be considered as a typic one for New Mexico. *Atriplex canescens* and *Koeberlinia spinosa* form low trees associated with a suffrutescent *Suaeda*, a tufted *Sporobolus* and occasional specimens of a *Lycium*. In low spots and along the margins of clay bottomed washes covered with a crust of alkali appears *Spirostachys occidentalis*. Toward the middle of the Tularosa Valley the principal facies consists of *Atriplex canescens* with areas in which *Yucca radiosa* or *Opuntia arborescens* are abundant. This formation also extends into the Painted Desert or desert of the Little Colorado River in Arizona. The vegetation is scattered and scanty and consists of such characteristic arid land forms as *Atriplex canescens*, *A. confertifolia*, *Sarcobatus vermiculatus*, *Dicoria Brandegei*, *Oxytaenia acerosa*, *Tetradymia canescens*, *Ephedra sp.*, *Yucca angustifolia* and cactuses of several genera. With these grow *Bouteloua oligostachya*, *Lupinus capitatus*, *Mirabilis multiflora*, *Riddellia tagetina* and *Zinnia grandiflora*. This desert flora reached the Painted Desert by way of the Grand Canyon of the Colorado.

Two plant formations in New Mexico may be distinguished where the sand dunes occur, viz: the sand dune formation and the dune hollow formation.

Dune Formation: The most characteristic plant of the dunes is Rhus trilobata [2] occurring in hemispheric bushes 4 to 8 feet high and binding the sand. Other characteristic woody plants of the dunes are Atriplex (Obione) canescens, two species of Aplopappus (= Chrysothamnus) and Yucca radiosa. — A marked peculiarity of the white sands is that a cotton wood (Populus) is occasionally found in the lower dunes, reaching a foot in diameter, but seldom more than 10 to 15 feet high while the mesquite is absent.

Dune Bottom Formation: The bottoms among the dunes have a characteristic vegetation of a grama grass (Bouteloua), clumps of Ephedra and about the water holes, Distichlis spicata,

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1) MAC DOUGAL, D. T.: Bot. Features of N. A. Deserts, loc. cit.; Course of Vegetation in southern Arizona. The Plant World. Sept. Oct. Nov. Dec. 1908; THORNBER, J. J.: Relation of plant Growth and Vegetation Forms to climatic Conditions. The Plant World XII: 1—7.

2) COVILLE, F. V. and MACDOUGAL, D. T.: Desert Botanical Laboratory of the Carnegie Institution, Publication 6, 1903.

Juncus balticus, both in alkaline soil, while in the shallow washes of this desert growth Statice (Limonium) limbatum.

A section from the base of the Sacramento Mountains, southwest through Alamogordo in to the Tularosa Desert shows five strips: (1) A strip of cacti, *Mamillaria* of several species, *Fouquiera splendens*, *Agave Parryi* and *Dasylirion texanum*, (2) the delta slopes from the mountain canyons, characterized by a nearly pure growth of creosote bush *Larrea mexicana* (= *Covillea tridentata*), the soil usually gravelly; (3) the mesquite *(Prosopis)* strip with thickets of *Opuntia fulgida*; (4) the area of *Atriplex canescens* and (5) the White Sands.

Bolson Basins Formation. Such basins have no established surface drainage, so that the rain water gathers at the lowest points forming mud flats, or shallow lakes. The vegetation of the flats consists of halophilous species. Black brush, Flourensia cernua and other shrubs, such as Larrea, are tolerant of the alkali. Some typic beach plants also occur, as: Lycium carolinianum, Sesuvium portulacastrum, Distichlis spicata, Salicornia ambigua, while the characteristic salt basin plants Spartina junciformis, Sporobolus airoides, S. Wrightii, Suaeda diffusa, S. suffrutescens, S. depressa, Sarcobatus vermiculatus. Chenopodium rubrum, Atriplex argentea, A. expansa, A. canescens, Eurotia lanata, Spirostachys occidentalis, Frankenia Jamesii are abundant, according to BRAY.

*The Gravel Hills Formation* in the neighborhood of Santa Fe, New Mexico are characterized by the presence of *Pinus edulis*, rarely over six feet in height, and *Juniperus occidentalis* on the ground between which occur *Actinella argentea*, *Pentstemon Fendleri*, *Astragalus cyaneus*, *A. diphysus*, *Lesquerella intermedia* (close to the ground) *Linum puberulum*, *Oenothera albicaulis* and others [1]).

*The Lava Beds Formation* of this desert (malpais of the Mexicans) are characterized by *Juniperus occidentalis*, *Opuntia fulgida*, (sometimes ten or twelve feet high) and the nut pine *Pinus edulis*. Great springs saturated with salt and alkali issue from the southern rim of the lava beds and here tufts of *Suaeda* and *Spirostachys* are set close against the lava wall[2]). Elsewhere near the Organ Mountains the plants of alkaline soil are *Bigelovia Rusbyi*, *Helianthus ciliosa* and species of *Sesuvium*, *Trianthema* and *Atriplex*.

*Mesa Formation*. The table land during the dry season is desolate, but during wet season presents great luxuriance of species in the genera: *Allium*, *Calochortus*, *Brodiaea*, *Bouteloua*, *Aristida*, *Poa*; *Agrostis verticillata*, *Setaria caudata* abound. Vegetation is mostly in patches. Such are *Pectis*, *Gutierrezia*, *Viguiera*, *Verbesina*, *Hymenatherum*, *Hymenopappus*, *Astragalus*, *Pentstemon*. In the slightly elevated, broken ground abound *Argemone*, *Oenothera*, *Sida*, *Malvastrum*, *Sphaeralcea*. One or more species of *Eriogonum*, will be found everywhere. *Bahia oppositifolia*, *Actinella odorata*, *Dysodia chrysanthemoides*, *D. Cooperi*, *Schkuhria*, *Hoffmannseggia*.

On the mesas in New Mexico occur Bouteloua oligostachya, Hilaria Jamesii, Aristida purpurea as the prevailing grasses with Sporobolus airoides, Oryzopsis micrantha, Poa Bigelovii,

1) HELLER, A. A.: Plant World, I: 21. Nov. 1897.
2) MAC BRIDE, THOMAS H.: The Alamogordo Desert. 1905.

Triodia (Tricuspis) pulchella, Bouteloua polystachya, Sporobolus cryptandrus, Koeleria cristata, Sporobolus (Blepharoneuron) tricholepis, Bouteloua eriopoda, Stipa pennata var. neomexicana.

The grasses of the meadows in central New Mexico are: Agrostis verticillata, Agrostis vulgaris, Agropyrum tenerum, Eatonia obtusata, Elymus Macounii, Polypogon monspeliensis and Juncus balticus. —

The wet meadows of Barfoot Park in the Chiricahua Mountains of southeastern Arizona at 8000 feet are characterized by BLUMER[1] as carpeted by Trifolium pinetorum, Hypericum formosum, Epilobium neo-mexicanum, Mimulus cardinalis (rare), Ligusticum Porteri, Ranunculus hydrocharoides and the fern Athyrium cyclosorum.

The bacterial flora of the air in the deserts of New Mexico, according to WEINZIRL, presents a somewhat limited number of species and this is due undoubtedly to the high winds which sweep uninterruptedly over wide stretches of barren country[2].

## 2. The Coniferous Forest Belts and high Summits.

Much of the forest in Arizona is on the Colorado Plateau and here it reaches its best development in the vicinity of the San Francisco Mountains. From here this magnificent pine forest stretches northward to beyond the Grand Canyon, westward to Bill Williams Mountains, and southward to the rim where the Colorado Plateau breaks down to the southern plains.

Coleogyne Association. The first 2600 feet of descent from the rim the Grand Canyon of the Colorado River is characterized by the presenee of trees. Below this the slopes are treeless and the vegetation of a desert character[3].

Coleogyne ramosissima, a rosaceous shrub, extends in an almost pure growth over the canyon terraces at an elevation of about 3600 feet in a soil seemingly well supplied with lime. The absence of many desert shrubs here is presumably connected with the narrowness of the canyon and a rainfall greater than in the open desert.

The Bradshaw Mountains, Mogallon Mountains, Mazatzal Mountains and the White Mountains may be considered southern extension of the Colorado Plateau. Of these mountains the Bradshaw are most poorly supplied with pine. The Mogollon and Mazatzal Mountains have wide strips of pine along their summits. The White Mountains are well timbered with *Pinus strobiformis* and *P. ponderosa.*

The altitudinal range of species in these mountains is not clearly defined, for the reason that the area presents a wide diversity of climatic conditions and exposures. The various tree species prefer the north or south slopes of the canyons. For example[4] at the headwaters of East Clearwater a tributary of the Little Colorado all the canyon slopes facing northward are timbered with Pseudotsuga Douglasii and Abies concolor (= Pseudotsuga Facies), while on the opposite sides of the canyon the entire forest is of Pinus ponderosa. Only a few individual red firs Pseudotsuga Douglasii seem to be able to live in the face of the intense mid-

1) BLUMER, J. C.: Muhlenbergia IV. 80.

2) WEINZIRL, JOHN: The bacterial flora of the semi-desert Region of New Mexico, with especial reference to the Bacteria of the Air. Journal Cincinnati Society Natural History, XIX: 211—242.

3) MAC DOUGAL: Botanical Features of North American Deserts. Publication 99, Carnegie Institution 1908: 32.

4) PLUMMER, F. G., RIXON, T. F., DODWELL, A.: Forest Conditions of the Black Mesa forest Reserve, Arizona. U. S. Geological Survey Professional Paper, 23, 1904.

day sun, and the lowest elevation at which this species occurs is 6,970 feet. Elsewhere the same disposition of trees is noticeable. North and west of Black River Pinus ponderosa prefers the western and southern slopes, but in the watershed tributary to Eagle Creek and Blue River its habits appear to be reversed, and it is found principally on the slopes facing the north; in fact it is found where Pseudotsuga Douglasii and Abies concolor would naturally be expected.

A noticeable feature in regard to the timber belts of the San Francisco, the Mogollon and the Black ranges in New Mexico is the striking distribution of the different species. On the San Francisco and Tularosa ranges the heaviest growth of mixed timber stands on the north-facing hillsides, while the southern ones are practically barren, being given up to scrub growths of small oaks and piñon pine, Pinus edulis. On the Mogollon Mountains the alpine species appear in their heaviest growth on the eastern slope, while on the Black range they are only found on the western slope. On the Mogollon Mountains the yellow pine ascends the western slope of the range very nearly to the summit, while on the east slope it does not reach within 500 feet. On the Black Range the conditions are reversed. The main cause of this striking difference is that each range has a gradual incline to the Gila River, the one to the east, the other to the west, and this gradual slope is naturally the more humid, and as humidity is an absolute necessity for the prolific growth of alpine species, wherever the slopes are steep, alpine species become reduced in number and disappear, and are replaced by more arid types such as oak, juniper and piñon pine.

The components of this forest and the piñon timber belt in Arizona are: *Pinus ponderosa*, *Picea Engelmanni*, *Pinus strobiformis*, *Pseudotsuga Douglasii*, *Abies concolor*, *Pinus flexilis*, *Picea Engelmanni* var. *franciscana*, *Juniperus pachyphloea*, *Populus trichocarpa*, *P. tremuloides*, *Quercus Gambelii*, *Q. Emoryi*, *Cupressus arizonica*, *Alnus rhombifolia*, *Platanus racemosa* mentioned in the order of their importance.

The low mountains south of the central range of Arizona are clothed with a different forest vegetation than that about San Francisco Peak, forming scarcely one per cent of the forest area. They are properly to be considered as included in the Mexican phytogeographic province and will be treated in connection with the Mexican flora. It may be well to briefly refer to the peculiarities of their flora at this point. The mountain summits show the presence of *Pinus ponderosa*, a tree of extensive range. Below this pine grow *Pinus edulis*, *P. cembroides* (a southern tree) and *Quercus undulata*. — The Chiricahua Mountains[1]) have in the spruce belt *Picea Engelmanni*, *Pinus ponderosa*, below which in the fir belt are *P. arizonica*, *Abies concolor*, while in the pine belt occur *P. chihuahuana* (entirely unknown north of the Santa Catalina Mountains) *P. Mayriana* and *P. cembroides*. Here two species of pine come together: *P. flexilis* (northern) and *P. strobiformis* (southern). At 8000 feet (2440 m) on these mountains we find the well-shaded northern slopes covered with a forest of *Pinus strobiformis, Pseudotsuga Douglasii* and *Abies concolor* associated with which are the heavy gold-crowned tussocks of *Dugaldea Hoopesii*, *Senecio eremophilus*, *Solidago Bigelovii* and *Helianthella quinquenervis arizonica*, while of smaller size near the cool ground are found *Cerastium texanum*, *Fragaria bracteata*, *Lathyrus graminifolius*, *Aphyllon*

1) Blumer, J. C.: On the plant Geography of the Chiricahua Mountains. Science new ser. XXX: 720—724.

*fasciculatum* and in the shadiest nooks the tall *Pedicularis Grayi* with fern-like foliage. A somewhat similar condition is found on the Huachuca, Santa Rita and Santa Catalina Mountains: *Pinus arizonica, P. cembroides, P. chihuahuana* occur on the Rincon Mountains while *P. ponderosa* is extremely rare apparently having reaches its southern limit. The flora of these ranges is clearly of a Mexican character [1].

Robinia neo-mexicana occurs in the Organ Mountains of New Mexico with Rosa Fendleri, Berberis trifoliolata, Dalea (Parosela) formosa, Linum rigidum, Erigeron flagellaris, Dryopetalon runcinatum, Aster ericaefolius, Lesquerella purpurea, Solanum tuberosum, Oxalis vespertilionis, Clematis ligustrina, Heuchera rubescens, Perezia nana, Gaura parviflora (almost) everywhere, G. coccinea, Gossypianthus rigidiflorus, Portulaca lanceolata, and the following ferns [2]:

Gymnopteris (Neurogramme) hispida Mett. commonly forming mats over the warmer rocks with Selaginella rupinicola Underw.;
Notholaena sinuata Lag. On calcareous and siliceous rocks in dry warm situations;
Notholaena sinuata var. integerrima Hook.;
Notholaena ferruginea Desv. (= N. bonariensis Willd.);
Notholaena Hookeri D. C. Eaton, the commonest fern of the range;
Notholaena dealbata Pursh, on steep limestone cliffs;
Cheilanthes Feei Moore, in crevices of vertical or overhanging rocks;
Cheilanthes tomentosa Link, in bunches at base of loose rocks in dry silicious soil and but partly protected from the sun;
Cheilanthes tomentosa var. Eatoni Baker;
Cheilanthes Fendleri Hook.;
Cheilanthes Lindheimeri Hook., forming long matted strings of vegetation in the crevices of the large granite boulders which fill the canyons;
Gymnogramma (Gymnopteris) Ehrenbergiana Kl.
Pellaea atropurpurea L. under the edges of rounded granite boulders in dry warm situations;
Pellaea ternifolia Cav.;
Pellaea Wrightiana Hook., common in loose dry soil under the edges of round granite boulders, growing best during the early spring months;
Pellaea intermedia Mett.;
Asplenium resiliens Kunze, only in a few places in dry soil under overhanging rocks;
Asplenium trichomanes L., under the rocks in wet, cool, shady places near running water;
Dryopteris filix mas L. in a cool moist canyon;
Phanerophlebia auriculata Underw., in cool, shady, moist situations in a single canyon;
Cystopteris (Filix) fragilis L. growing in open canyons in wet soil;
Woodsia mexicana Fée, rare on the higher slopes of the Organ Mountains.

*Piñon Pine Formation.* Ascending the San Francisco range of mountains and also the Mogollon Mountains the first distinctive mountain belt is that of the piñon pine *Pinus edulis* (5,700—7,000 feet). *P. edulis* is associated with *Juniperus monosperma* and *J. pachyphloea, Quercus agrifolia, Q. Emoryi*, and such shrubs as *Berberis Fremontii, Rhus aromatica* var. *trilobata, Holodiscus discolor* with *Yucca baccata, Opuntia arborescens, Ephedra antisyphilitica, Mentzelia albicaulis, Pectis angustifolia* and along creeks *Platanus occidentalis, Populus monilifera, Schrankia uncinata.* Near the Grand Canyon of the Colorado and again at Walnut Canyon where the lava rock gives place to lime-

1) TOUMEY, J. W.: Pines Forests of southern and central Arizona 1897.

2) PLANK, E. N.: Botanical Journey through New Mexico. WOOTON, E. O.: The Ferns of the Organ Mountains. 1903.

stone these shrubs are joined by *Cowania mexicana*, *Spiraea millefolium*, *Robinia neomexicana* and *Yucca angustifolia* is replaced by *Yucca baccata*. *Juniperus californica* var. *utahensis* also grows at the Grand Canyon. A dense chaparral of *Fallugia paradoxa* forms extensive thickets east of O'Leary Peak and occurs sparingly over most of the piñon belt even extending down into the desert in places [1].

At the brink of the Grand Canyon opposite Point Sublime is a dwarf forest of peculiar aspect, having a uniform height of about 5 meters consisting of Cercocarpus ledifolius, Pinus edulis, and Juniperus californica var. utahensis. Mingled in this forest are Berberis Fremonti, Spiraea millefolium and along its edges are extensive fields of Artemisia tridentata which reaches here its southern limit, and Yucca baccata, with several kinds of cactuses. In other directions it gives place to thickets of Quercus Gambelii and Robinia neomexicana. This the piñon belt of the Grand Canyon, differs from that about San Francisco Mountain because of the presence here on the Coconino Plateau of carboniferous limestone, such plants as Cowania Mexicana, Berberis Fendleri, Spiraea millefolium, Yucca baccata, Robinia neo-mexicana growing at the Grand Canyon, but not in the lava soils of the piñon belt about San Francisco Mountain [2].

San Francisco Mountain [3] rises from an elevated open somewhat barren table-land which is the continuation of the high plateaus of New Mexico and Utah. It is traversed by a number of profound canyons. It supports some isolated ridges and peaks besides the second region above-named. Upon them occurs: Pinus ponderosa, P. edulis, Juniperus monosperma, J. pachyphloea, Fraxinus velutina (= F. pistaciaefolia), Quercus Gambelii, Q. oblongifolia, occasionally Juglans rupestris. Among the smaller trees and shrubs are Morus celtidifolia (= M. microphylla), Cercocarpus parvifolius, Forestiera neo-mexicana, Garrya Fremontii, Ribes aureum, Arctostaphylos pungens and small oaks Quercus undulata (= Q. grisea), Q. hypoleuca. The level portion of the plateau is destitute of everything larger than shrubs with which occur Yucca baccata, Y. angustifolia (= Y. glauca), Artemisias and Ephedras.

The piñon belt, in the Lincoln forest reserve, New Mexico, which comprises the country between the Rio Grande del Norte and the Rio Pecos and includes such ranges as the Sacramento Mountains, Sierra Blanca, or White Mountains, Capitan and Jicarilla Mountains, occurs between 5,000 and 6,400 feet. The species of this belt nearly the same but with Negundo aceroides and Mexican walnut Juglans rupestris. Along Three Rivers, extending out into the desert about 10 miles beyond the lower limit of the pinion belt is a narrow broken fringe of deciduous trees consisting in the main of the same Juglans rupestris, Negundo aceroides (= Acer negundo), Fraxinus and Robinia neomexicana [4].

The piñon belt west of the Pecos Valley in Texas covers the lower slopes of the mountains extending on southwest slopes nearly or quite to the tops of most of the peaks, but on the northeast slopes of the Guadalupe, Davis

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1) LOEW, O.; FERNOW, B. E.; MERRIAM, C. H. (see general bibliography); RUSBY, H. H.: General floral Conditions of the San Francisco and Mogollon Mountains. Trans. N. Y. Acad. Sci. VIII: 76.

2) MERRIAM, C. HART: Results of a Biological Survey of the San Francisco Mountain Region, 1890; LOWELL, PERCIVAL: The Plateau of the San Francisco Peaks in its Effect on Trees. Bull. Amer. Geogr. Soc. XLI May and June 1909.

3) Consult also in addition to the papers mentioned above RIXON, THEODORE, F.: Forest Conditions in the Gila River forest Reserve, New Mexico, Professional Paper No. 39, Series H. Forestry 13, U.S. Geological Survey 1905, where a description of the forests on the San Francisco, Tularosa, Mogollon and Black Mountains is given with names of species.

4) PLUMMER, FRED. G. and GOWSELL, M. G.: Forest Conditions in the Lincoln forest Reserve, 1904.

and Chisos Mountains it ranges as high as 6000 feet (1830 m). On the steep and slopes of these mountains the difference of zone level on opposite sides is often 2000 or 3000 feet, increasing with the steepness and barrenness of the slope. Some of the most characteristic plants are *Pinus edulis*, *P. cembroides*, *Juniperus pachyphloea*, *J. monosperma*, *J. flaccida*, *Quercus grisea*, *Q. Emoryi*, *Adolphia infesta*, *Nolina texana*, *Mimosa biuncifera*, *Cercocarpus parvifolius*, *Fallugia paradoxa*, *Yucca baccata*, *Agave Wislizeni*, *A. applanata*[1]).

*Upper Coniferous Forest Formation.* The characteristic tree of this belt is *Pinus ponderosa* (Pinus ponderosa Facies) which forms one of the most beautiful forests in existence, above an altitude of 7000 feet (2100 meters) and extends up as high in some of the parks as 8800 feet (2675 meters). As a distinctive species, however, it loses its character at about 8200 feet (2500 meters) where it is invaded and soon after replaced by *Pinus flexilis*, *Pseudotsuga Douglasii* and *Populus tremuloides*; *Quercus Gambelii* grows in clumps with the bull pine at an elevation of 8000 feet. The herbaceous plants of this belt are *Campanula Parryi*, *Frasera speciosa*, *Gilia aggregata*, *G. attenuata*, *Oxybaphus angustifolius (Allionia linearis)*, *Oxytropis Lamberti*.

This forest belt reaches its highest development about San Francisco Mountains. From here it stretches north to and beyond the Grand Canyon of the Colorado River westward to Bill Williams Mountain and southward to the rim where the Colorado Plateau breaks down to the southern plains.

In the Sacramento, White, Capitan and Jicarilla Mountains the belt of *Pinus ponderosa* ranges from 6400 to 9000 feet. The principal trees are with the main pine *Pseudotsuga Douglasii*, *Abies concolor*, Mexican white pine, *Pinus strobiformis* and *Quercus undulata*. Along the streams and canyons are *Robinia neomexicana*, *Acer grandidentatum*, *Populus angustifolia*, and other deciduous species overlapping from the piñon belt.

Growing with the main pine on the Mazatzal Mountains at the higher elevations are scattered specimens of *Pinus flexilis*, *Abies concolor*, *Pseudotsuga*, while *Pinus edulis* exists at lower elevations. In the White Mountains the same general disposition seems to prevail while *Cupressus arizonica* lines the canyons. In Texas a pine forest formation exists on the higher Guadalupe and Davis Mountains[2]). The chief elements of the formation are *Pinus ponderosa* on Guadalupe Peak at 9000 feet and on Davis Mountains. Next to this prevalent pine is *Pseudotsuga Douglasii*, *Pinus flexilis*, while on the lower slopes are *P. edulis*, *Juniperus pachyphloea*, *Quercus Emoryi* (in the Canyon), *Q. Gambelii*.

A few of these reach the summits of the highest mountains in the great bend of the Rio Grande River in Western Texas, but scarcely in force to change the Mexican i. e. upper Sonoran character of the flora. This belt

1) Bailey, Vernon: Biological Survey of Texas, 1905.

2) Bray, W. L.: The ecolog. Rel. of Vegetation of Western Texas, 1901. Havard, V.: Flora of western and southern Texas, 1885.

confined to the Chisos, Davis and Guadalupe Mountain ranges from 6000 feet on northeast slopes to the tops of the ranges. It represents the Transition Zone of MERRIAM[1]. It is the home of the wild potato *Solanum tuberosum* var. *boreale*.

That characteristic plants of the above three mountain ranges are displayed in the list:

| | Guadalupe | Davis | Chisos |
|---|---|---|---|
| Pinus ponderosa Dougl. | + | + | + |
| » flexilis James | + | + | — |
| Pseudotsuga Douglasii Carr. (= P. mucronata Raf.) | + | — | + |
| Acer grandidentatum Nutt. | + | + | + |
| Quercus grisea Liebm. | + | + | + |
| » Emoryi Torr. | — | + | + |
| » texana Buckley | — | — | + |
| » undulata Torr. | + | — | — |
| Prunus serotina Ehrh. var. acutifolia | — | + | + |
| Rhamnus Purshiana DC. | + | + | + |
| Amelanchier alnifolia Nutt. | + | — | — |
| Ceanothus Greggii A. Gray | + | — | — |
| Robinia neomexicana A. Gray | + | — | — |
| Solanum tuberosum L. var. boreale A. Gray | + | + | — |

The timber of the Davis Mountains is typic. Omitting the small areas of Pinus ponderosa, the mountains, ridges and mesas are covered with trees whose short trunks and brown crowns produce a park-like appearance.

The grasses of the pine forest are Mühlenbergia Porteri, Panicum bulbosum, Poa Eatoni, Bouteloua oligostachya, Stipa comata, Andropogon hirtiflorus, Agropyrum pseudorepens, Aristida arizonica and longiseta. — Everywhere through the forest are beautiful open parks Park Formation: from a few acres to several miles in area. Here are Stipa neomexicana, S. comata, Senecio Douglasii, Aster (Machaeranthera) tanacetifolius, A. (M.) canescens, Hymenopappus mexicanus, Actinella (Picradenia) Rusbyi, Gilia multiflora, Eriogonum cernuum, Astragalus Hosackiae, many Eritrichiums. About the springs grow Iris missouriensis, Epilobium paniculatum, Campanula Scheuchzeri.

Up the small rough canyons formed by erosion creep many lowland plants and down them come many from the highlands producing a varied flora (Canyon Formation), viz: Pentstemon Palmeri, Prunus demissa, Spiraea millefolium, Holodiscus discolor, Cowania mexicana, Fendlera rupicola, Sambucus glaucus, Lonicera involucrata, Lupinus rivularis, Ivesia depauperata, Helianthus Maximiliani. — Spiraea caespitosa, a stout shrub, grows on the rocky margins of these canyons exposed to sweeping storms. In its company grow Eriogonum deflexum, E. microthecum and E. flavum. — Barfoot Park in the Chiricahua Mountains (8000 feet) was characterized

1) BAILEY, VERNON: Biological Survey of Texas. North American Fauna No. 25, U. S. Biological Survey 1905: 37—38.

by a scattered growth of Pinus arizonica beneath which beginning in June appear a succession of flowering plants. The season opens with Pentstemon Torreyi and ends in autumn with Gymnolomia multiflora. The deeper soil mountains Commelina dianthifolia, Cerastium sericeum, Achillea lanulosa, Cacalia decomposita, etc. On stony knolls in sunny places grow Allionia pratensis, Anthericum Torreyi, Calogania longifolia (of a royal purple), Phaseolus parvulus, P. Wrightii, Verbesina longifolia and Viguera cordifolia with great tubers of stony hardness. At the base or well-protected slopes are found Delphinium scopulorum, Vicia americana, Oenothera Hookeri and Solanum tuberosum boreale.

*Subalpine Coniferous Forest Formation.* 1) Balsam Fir Belt: *Pseudotsuga Douglasii* is the distinctive tree of this belt (8200—9200 feet = 2500—2800 meters) associated with *Pinus flexilis* var. *megalocarpa*, *Abies subalpina* and *Populus tremuloides*. The accompaning species are *Actaea spicata*, *Berberis repens* (= *B. aquifolium*), *Ceanothus Fendleri*, *Gentiana*, *Geum triflorum*, *Ribes Rusbyi*, *Viola canadensis* var. *scopulorum*.

2) Spruce Belt: The characteristic trees of this belt (9200—10,5000 feet = 2800—3200 meters) are *Picea Engelmanni* and *Pinus aristata*.

In the ravines in this belt are Potentilla Thurberi, Mertensia paniculata, Pentstemon glaucus var. stenophyllus, Thalictrum Wrightii, Ligusticum scopulorum, Hieracium Fendleri, Frasera speciosa, Habenaria Thurberi, Ribes lacustre. The additional prominent secondary species of this belt are Aquilegia chrysantha, Lathyrus arizonicus, Pirola chlorantha, P. uniflora, Ribes setosum, Solidago multiradiata, Zygadenus elegans.

3) Sub-Alpine or Timber-line Belt: The trees which reach timber line on the San Francisco Range (11,500 feet = 3500 meters) are *Picea Engelmanni* and *Pinus aristata*, which exist as stunted and prostrate specimens.

The subalpine belt in the Sacramento, White, Capitan and Jicaralla Mountains is found between 9,000 and 11,000 feet. The principal tree is Picea Engelmanni, with subordinate amounts of Abies concolor, Pseudotsuga, Mexican white pine, Pinus strobiformis and aspen, Populus tremuloides generally in groves. In this narrow belt, according to Merriam[1]) a number of hardy little plants attain their maximum development, decreasing in abundance both above and below. Such are: Gentiana tenella, G. barbellata, Cerastium alpinum var. Behringianum, Corallorhiza multiflora, Phleum alpinum, Heuchera rubescens, Pedicularis Parryi, Draba aurea, Epilobium saximontanum, Luzula spadicea var. parviflora, Potentilla dissecta, Primula Parryi, Veronica alpina (= V. Wormskjoldii), Sedum rhodanthum and Saxifraga debilis. Many of them are circumpolar species found throughout the northern parts of America coming south on the high mountains.

The grasses are Agropyrum violaceum, Agrostis hiemalis (= A. scabra), Bromus Richardsoni, Deschampsia caespitosa, Festuca ovina var. pseudovina, Koeleria cristata, Phleum alpinum, Poa coloradensis, P. Eatoni and Trisetum subspicatum.

4) *Alpine Formation.* At the summit of San Francisco Mountain only lichens grow. One or two hundred feet below begins the growth of alpine plants. Some of these alpine plants occur on the higher peaks of the Rocky Mountains, the Sierra Nevada and Cascade ranges, and Mount Washington. In brief they inhabit the arctic regions of the globe and extend far south on the higher mountain ranges.

Among these species may be mentioned Sedum rhodanthum, Luzula spadicea var. parviflora, Primula Parryi, Pedicularis Parryi; Androsace septentrionalis, Alsine (Arenaria) verna, Cerastium

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1) MERRIAM, C. HART: loc. cit.

alpinum, C. arvense, Saxifraga debilis, S. caespitosa, S. flagellaris, S. nivalis, Silene acaulis, Cystopteris fragilis, Oxyria digyna, Festuca brevifolia (= F. brachyphylla), Sagina Linnaei (= S. saginoides), Stellaria umbellata (Alsine baicalensis), Thlaspi alpestre, Trisetum subspicatum and Sibbaldia procumbens.

## D. Mohave District.

This phytogeographic district comprises the Mohave Desert and adjacent territory including Death Valley and Ralston Desert.

The Mohave Desert lies on the north side of the San Bernardino Range and its continuing spur on the Chuckawalla Mountains which ranges separate it from the Colorado Desert on the south. It is limited in an eastern direction by the Colorado River and in a northeastern direction by the Kawich and Desert Mountain ranges. Its whole surface is cut up by short isolated ranges and "lone mountains" which are surrounded by sloping mesas, or enclose basins whose lowest portions are occupied by dry lakes. Some of these are level expanses of hard plastic clay, smooth and bare as a table-surface and bordered by a narrow strip of nitrophilous vegetation. Receiving the scanty rain water that runs down from the bare hill about them, they at times may be transformed into tenacious mud, or covered at times with a few inches of water [1]. Or the surface layers of these desert basins may consist of what prospectors call "self-rising soil", a loose alkaline powder slightly crusted over, or a snowy incrustation of soda salts. — The flora of the Mohave District shows a marked influence of the vegetation of the Nevada, or Great Basin District, and for this reason it has been placed in the classification as a part of the Great Basin phytogeographic region, distinct from that of the flora of the Sonoran deserts to the south. The difference in the character of the two floras is only in part due to climatic causes, but it is largely influenced by the topography of the country. In the case of the Mohave Desert, the migration current from eastern Utah and Nevada would meet with no considerable obstacle until it reached the San Bernardino Range and its continuation. The distinctness of the two desert floras is further emphasized by a consideration of the zonal distribution of their respective floras.

The Larrea belt is presented in both the Mohave and Colorado Deserts. But, however, useful this shrub (*Larrea mexicana = Covillea tridentata*) may be as the biologic index of larger divisions, it is of less importance in the study of smaller areas. Above the Larrea belt of the two deserts occurs in the Mohave Desert a belt of *Yucca brevifolia* (3000—4000 feet = 915—1220 m). In its normal limits *Juniperus californica* is mingled with the yucca, but does not accompany it far above them. The piñon belt is above the yucca belt and is characterized by the presence of *Pinus monophylla* between 4000 and 6000 feet (1200—1830 m). In the upper end of Antelope Valley, according to PARISH, the orographic confusion there has given rise to a phyto-

geographic anomaly. Here *Pinus sabiniana*, *Quercus Douglasii* and *Q. Wislizeni*, trees of the western slope of the Sierra Nevada throughout central California, come through Tejon Pass and the unusual sight is presented of foot hills clothed with an almost unmixed growth of scrub oaks. Here too are found *Aesculus californica*, *Balsamorrhiza deltoides*, *Gilia tricolor*, *Layia heterotricha* and *Collinsia Torreyi* which have entered through the same gap to the eastern deserts.

The western or elevated part of the Mohave Desert is noted for *Yucca arborescens* and in places this tree is associated with *Juniperus californica.* Eastward the juniper ends and the creosote bush *Larrea mexicana* appears and in lower levels becomes except in the wash, the prevailing bush.

The northeastern element, which preponderates over the southeastern, consists of such genera as: Actinella, Amsonia, Atrichoseris, Bouteloua, Cleomella, Eurotia, Forestiera, Glossopetalon (Forsellesia), Glyptopleura, Kochia, Lygodesmia, Monoptilon, Phellopterus, Purshia (= Kunzia), Stanleya, Salazaria and Syntrichopappus while the southeastern element comprises a few genera: Canotia, Coleogyne, Fallugia, Psilactis[1]. The northeastern genera are those which extend into Nevada, Utah and the Great Basin, and southeastern genera are those whose range is into Arizona, or into northern Mexico.

## 1. The lower Desert Formations.

Larrea Belt. The most generally distributed shrub of this desert is *Larrea Mexicana* (= *Covillea tridentata*), ascending from the lowest elevation that of Death Valley to about 1500 meters on the mountains. Associated with it at about the same elevation grows *Franseria (Gaertneria) dumosa.* The upper limit of this belt which MERRIAM calls the "Lower Sonoran Zone", is only a little below the lower limit of timber.

*Mesa Formation. Larrea* and *Franseria* are the commonest shrubs of the mesas, but at various localities some one or more of the following species are often abundant according to COVILLE[2]).

Acamptopappus sphaerocephalus, Amphiochyris Fremontii, Aster mohavensis, Atriplex confertifolia, A. hymenelytra, Bebbia juncea var. aspera, Cassia armata, Cereus Engelmanni, Echinocactus polycephalus, Opuntia basilaris, O. echinocarpa, Ephedra californica, Hymenoclea salsola, Krameria parvifolia, Lycium Andersoni, Salazaria mexicana, Tetradymia comosa, Yucca arborescens, Y. macrocarpa. — Some of these plants are confined to the upper altitudes of this belt, viz: Acamptopappus sphaerocephalus, Aster mohavensis, Yucca arborescens while Hymenoclea salsola and Lycium Andersoni are common throughout it. The perennials common on the mesas are Euphorbia polycarpa, Cladothrix oblongifolia, Lepidium Fremontii and Oxybaphus laevis, while as annuals occur Leptosyne Bigelovii, Plantago patagonica var. gnaphalodes (= P. Purshii), Sisymbrium canescens, Gilia floccosa, Chorizanthe rigida, Cleomella obtusifolia, Eschscholtzia minutiflora, Encelia eriocephala, Atrichoseris platyphylla.

*Canyon Rocky Slope and Sandhill Formations.* Growing in the shade of rocks or in their crevices in the canyons, in the coarse pebbly plains and on the dry sandy hills may be designated the following associations.

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1) PARISH, S. B.: loc. cit. see also page 289—293.

2) COVILLE, F. V.: Botany of the Death Valley Expedition. Contributions U. S. National Herbarium IV: 21. Washington, 1893.

1. Canyon shrubs. Bigelovia teretifolia, Aplopappus (Chrysoma) cuneatus, Brickelia (Coleosanthus) atractyloides. Hofmeisteria and such perennials as Arenaria macradenia, Eucnide urens, Nicotiana trigonophylla while as annuals occur Parietaria debilis, Pterostegia drymarioides and Phacelia (Macrocalyx) micrantha. — 2. Rocky Slope Association: This also occupies coarse pebbly plains where Larrea mexicana meets with Yucca brevifolia, Opuntia ramosissima, Echinocactus cylindraceus, Yucca baccata, Atriplex canescens; Fouquiera splendens and Opuntia arborescens[1]). The plants of the desert sand hills are Coldenia Palmeri, Hilaria (Pleuraphis) Jamesii, Eriogonum inflatum, Triodia (Tricuspis) pulchella, Mammillaria barbata, Chorizanthe rigida, Psathirotes annua.

*Alkaline Marsh Formation.* The surface of an alkaline marsh is barren of plants, but the margin shows many characteristic plants. At Bennett Wells, Death Valley, according to COVILLE, there occur first a circumarea a few meters broad of *Spirostachys* (*Allenrolfea*) *occidentalis*; next, a similar circumarea of *Juncus Cooperi*; and third, an association of *Sporobolus airoides* and *Pluchea sericea* about 300 meters broad. *Distichlis spicata* (= *D. maritima*) occurs sparingly in the second and third circumareas. The fourth circumarea consists of *Prosopis juliflora*, *Atriplex canescens* and occasionally *Suaeda suffrutescens*. *Larrea* and *Atriplex polycarpa* make the next circumarea and *Larrea* distinguishes the sixth, while on the outer margin nearest the preceeding belt grow *Atriplex hymenelytra* and in the other direction *Fransera dumosa*, *Eriogonum inflatum* and *Hymenoclea salsola*. The flora of clayey soil charged with sodium salts comprises the same *Spirostachys*, *Salicornia* and *Brizopyrum spicatum*.

The Stream Banks comprise the usual formation of common plants, viz. Populus Fremonti, Prosopis pubescens, Salix longifolia (= S. interior), S. nigra var. venulosa, Apocynum cannabinum, Berula angustifolia (= B. erecta), Eleocharis rostellata, Juncus balticus, Nitrophila occidentalis, Scirpus lacustris var. occidentalis. S. Olneyi, S. pungens (= S. americanus), the widely distributed Typha angustifolia and the european annual grass Polypogon monspeliensis.

## 2. The elevated Tree Formations.

*Coniferous Forest Formations.* Certain of the desert mountain ranges between the Sierra Nevada and the Colorado River rise to a sufficient altitude to be crowned with coniferous timber. A belt of *Pinus monophylla* about 1800 feet (600 meters) in width with *Juniperus utahensis* forms what MERRIAM calls the Upper Sonoran Zone.

Associated with the above trees are Salvia carnosa, Ceanothus Greggii, Artemisia tridentata, Purshia (Kunzia) glandulosa, Garrya Veatchii, G. flavescens, Ribes leptanthum, R. brachyanthum, while between the lower limit of Juniperus and the upper limit of Larrea are found Grayia polygaloides (= G. spinosa), Tetradymia glabrata, T. spinosa, Eurotia lanata, Ephedra viridis, Coleogyne ramosissima, Dalea (Parosela) polyadenia (in the northern part of the region), Prunus fasciculata and Yucca arborescens. In the Charlestown Mountains above the belt of Pinus monophylla is a forest belt of Pinus ponderosa var. scopulorum and on the eastern slope of the Sierra Nevada Mountains occurs a forest of Pinus Jeffreyi.

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1) LOEW, OSCAR: Surveys west of the one hundredth Meridian in California, Nevada etc. by GEORGE M. WHEELER, 1876: 224.

Davidson Glacier,

and Coniferous Coastal Forest of Sitka spruce, *Picea sitchensis*, and Western Coast hemlock, *Tsuga Mertensiana* (= T. heterophylla Sarg.), both extending up mountain slopes to 2,600 feet (800 m). Coast of Alaska near the Head of Lynn Canal Lat. 59° N., Long. 135° W.

Between timber line and this pine belt is a belt characterized by *Pinus flexilis* and *P. aristata.* In none of these desert mountains does a true timber line exist, but northward the White Mountains of Nevada and southward the San Bernardino Mountains extend above this limit. According to COVILLE an abnormal condition of affairs exists on the Panamint where owing to the absence of *P. ponderosa* var. *scopulorum*, which reaches its western limit in the Charlestown Mountains, *P. monophylla* grows to an unusually high altitude and *P. flexilis* and *P. aristata* unusually low, so that the bull pine belt appears to be crowded out entirely, although still marked by the presence of *Juniperus occidentalis* and *Cercocarpus ledifolius.*

# Chapter IV. North American Temperate Zone: Pacific Section.

## 1. Sitkan Region.

This region extends from Cook Inlet south to the fifty-first degree of north latitude (the northern limit of *Pseudotsuga Douglasii*), west of the continental divide and includes coastal Alaska and British Columbia with the more northern portion of Vancouver Island. In its northern extension, far to the subarctic territory along the southern tributaries of the Yukon River, it mingles with the flora of the glaciers, the arctic plant associations and the timber boundary of the northern coniferous forest the western pacific floral element has a very interesting complexity, as shown by the illustration of the Davidson Glacier (plate XIV.) It is a region characterized by deep fiords like Norway, but with a far richer forestation. Fogs and heavy rains are frequent and the snow line on the unbroken chain of coastal mountains is at 2,500 and 3,000 feet and numerous large glaciers descend from the snow fields to the shore. The coast is fringed by hundreds of forest-clad islands which form an inland passage from Vancouver Island north to 59° N. lat.

### 1. Halophytic Formations.

*Marine Algal Formation.* The algae of the Pacific coast north of Puget Sound extending northward to and including those of Bering Sea and which characterize that region are *Odonthalia aleutica*, *Polysiphonia bipinnata*, *Euthora cristata*, *Rhodymenia pertusa*, *Constantinea rosamarina*, *Fucus evanescens* var. *megacephalus*, *Agarum Turneri*, *Cymathere triplicata*, *Laminaria Bongardiana*, *L. bullata*, *Dictyosiphon foeniculaceus* and *Myelophycus intestinalis* [1]). Several shelves of marine vegetation may be distinguished on the Alaskan coast.

Sublittoral Shelf. The marine algae of this shelf are: Costaria Turneri, Porphyra amplissima (on rocks), Iridaea membranacea, Gigartina pacifica (on rocks), Ahnfeldtia plicata (on rocks), Euthora cristata (abundant), Rhodymenia pertusa (on rocks), Rhodymenia palmata (on rocks),

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1) SAUNDERS, DE ALTON: See Bibl. p. 55, and: Harriman Alaska Expedition, Vol. V. Cryptogamic Botany, 1904: 155—211.

Polysiphonia arctica, P. bipinnata, Ptilota asplenoides, P. plumosa, Antithamnion boreale, Ceramium rubrum, Gloiopeltis furcata, Odonthalia aleutica, O. Kamtschatica, Plocamium coccineum var. uncinatum, Nitophyllum rutbenicum, Delesseria Baeri, D. sinuata, D. decipiens, Gloiosiphonia californica, Dumontia filiformis, Cryptosiphonia Grayana, Dilsea Californica, D. arctica, Lithothamnion compactum, L. glaciale, L. laeve, Clathromorphum circumscriptum, Lepidomorphum Yendori, Amphiroa tuberculosa, A. planiuscula (on shells), Corallina arbuscula, C. pilulifera var. filiformis, Agarum Turneri, A. Gmelini, Hedophyllum sessile, Alaria laticosta, A. fragilis, A. lanceolata, A. cordata, Laminaria bullata, L. Bongardiana, L. solidungula, L. saccharina, Chorda filum and the following algae on the rocks: Myelophycus intestinalis, Scytosiphon bullosus, Eudesme virescens, Chordaria flagelliformis, Ralfsia deusta, R. clavata.

Elittoral Shelf: Macrocystis pyrifera, Nereocystis priapus, Cystophyllum lepidium, Desmarestia viridis, D. aculeata, Agarum Gmelini.

Littoral Shelf: The most abundant seaweed on the northwest coast is Fucus evanescens forma macrocephalus. It is found in all quiet bays and protected places from Puget Sound to Bering Sea, forming the characteristic light brown covering extending some distance above the average tide level. In many places, the plant is not covered by salt water more than twice a month. It is able to thrive from the moisture in the atmosphere. This species and Plylaiella littoralis extend farthest up the mouths of streams and fresh water bays[1]) and there are many other algae in this shelf, viz. the characteristic: Ulothrix flacca, Phyllitis fascia; on rocks: Coelodesme bulligera, Soranthera ulvoides, Leathesia difformis, Chordaria abietina; Halosaccion spec. Ceratothamnion, Microcladia borealis, Rhodomela spec. and Lithophyllum Farlowii.

*Strand Formation.* Little is known of the strand flora of Alaska. The only observations on the beach vegetation obtainable for this account were made by FREDERICK FUNSTON at Yakutat Bay[2]), where stretching along the beach from Cape Phipps to the Ankau is a treeless strip of low sand dunes lying between high tide mark and the margin of the forest, a distance of 100 yards. Elsewhere, similar dunes occur. The vegetation of these sand dunes is less dense and rank than that of the forest openings, though in some localities many acres are covered with *Fragaria chiloënsis.* On the grassy dunes near the Malaspina Glacier, this plant is found in immense quantities. The coarse grass of these beaches is *Elymus arenarius*, associated with *Lathyrus maritimus*, *Arabis hirsuta*, *Moehringia lateriflora*, *Castilleja miniata*, *Ranunculus Nelsoni*, *Lupinus nootkaensis* var. *unalaskensis* etc.

## 2. Coniferous Forest Formations.

On a previous page of this book[3]) mention has been made of the fact that the forest of the interior of Alaska is of different origin from that of the inmediate coast, representing the northwestward extension of the coniferous forest, which stretches uninterruptedly from Labrador westward to Bering Sea. This forest does not concern us at this place. The coast forest of the southeastern portion of Alaska, lying west of the coast ranges of mountains is a dense one. This forest may be considered to be the northern extention of

1) SAUNDERS, DE ALTON, loc. cit. p. 196.

2) COVILLE, FREDERICK V. and FUNSTON, FR.: See Bibl. p. 52. Botany of Yakutat Bay, 331—332.

3) See ante page 208.

the one at Puget Sound, resembling that of Puget Sound and western British Columbia, although *Pseudotsuga Douglasii*, does not reach Alaska, while *Abies grandis*, *Acer grandidentatum* are absent from the Alaska forest and *Thuja gigantea* (= *T. plicata*) common on Prince of Wales Island is rare, if it exists at all north of latitude 56° N. It lacks the pines, with the exception of the inferior *Pinus contorta* which here and there occupies swampy and dry gravelly situations. *Chamaecyparis nootkatensis* is limited in a westward direction by Yakutat Bay with evidence of its existence in a few spots on Prince William Sound. The Oregon alder, *Alnus oregona*, is found abundantly, as far, as the foot of La Perouse Glacier, a little south of Mt. Fairweather, but is entirely absent at Yakutat Bay and farther west. Excepting, then, the more or less sporadic occurrence of the species mentioned the coast forest is composed of two trees: Picea sitchensis and coast hemlock Tsuga Mertensiana (= *T. heterophylla*) [1]).

From the edge of tidewater (see plate XIV) these two trees grow up to the timber line, which varies in elevation from 2,500 to 4,000 feet, everywhere in dense serried masses, covering all the islands and the seaward slopes of the mountains of the mainland, which shut off the moisture from the interior. *Abies subalpina* (= *A. lasiocarpa*) in dwarfed specimens from the interior remains the only timber-line tree at the White Pass. Other woody plants at timber line, dwarfed in size (Krummholz), are *Juniperus communis* var. *nana*, *Salix fulcrata*, *Ribes bracteosum*, *Spiraea betulifolia*, *Potentilla fruticosa*, *Amelanchier canadensis* var. *oblongifolia* and *Cladothamnus pirolaeflorus*. The following ericaceous plants also occur here: *Vaccinium caespitosum* var. *arbuscula*, *V. uliginosum*, *Bryanthus glanduliflorus*, *B. empetriformis*, *Cassiope Mertensiana*, *C. Stelleriana*, *Ledum palustre* and the ecologically related *Empetrum nigrum*.

Numerically in this forest the coast hemlock, *Tsuga Mertensiana* is the most common species, forming usually 70 to 80 per cent of the mixture (Tsuga Mertensiana Facies). The spruce *Picea sitchensis* occasionally preponderates, especially along the water courses (Picea sitchensis Facies) and on newly formed moraines until the western limit of the coast hemlock *Tsuga Mertensiana* is reached at Prince William Sound. Farther west, however, the spruce, *Picea sitchensis*, alone forms forest, or open groves, as on the shores of Cook Inlet and Kadiak Island where it meets the vanguard of the interior forest of Alaska derived from the Atlantic coniferous forest stretching across the continent. This is indicated by the presence of *Picea nigra* (= *P. mariana*) in small peat bogs associated with *Empetrum*, *Ledum latifolium*, *Betula glandulosa*. On the northwest side of Cook Inlet are found *Picea alba* (= *P. canadensis*). *Betula papyrifera* (the most abundant tree), *Populus balsamifera*

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1) Meehan, Thomas: Alaska Forests. Gardener's Chronicle third ser. X 1891: 732. The forests of Alaska (Editorial). Garden and Forest X: 379; Fernow, B. E.: Forests of Alaska; Harriman Alaska Expedition II. 1904: 135—256.

and *P. tremuloides*[1]). *Chamaecyparis nootkatensis* is scattered through this forest at elevations of about 1,000 feet, although it descends to the waters edge.

Where the mountain streams reach the sea are flats and beaches where the forest is bordered by Alnus sinuata, A. oregana, Salix sitchensis while Populus trichocarpa and P. balsamifera with Acer glabrum form groves in similar situations (with at the mouths of rivers and on rocky coasts) R. prostratum, Juniperus communis var. nana, Amelanchier botryapium var. oblongifolia, Arctostaphylos uva-ursi, Empetrum nigrum, Loiseleuria procumbens, Polypodium vulgare, Cryptogramme acrostichoides, C. Stelleri, Nephrodium spinulosum, Aspidium lonchitis, Woodsia scopulina, Lycopodium selago, L. annotinum, L. sitchense, L. clavatum, L. complanatum, Selaginella rupestris, Festuca rubra var. arenaria, Poa arctica var. elongata, Trisetum subspicatum, Agrostis canina, Hierochloë alpina, Carex Gmelini, Draba incana var. confusa, Saxifraga punctata, Heucbera glabra, Diapensia lapponica, Collomia gracilis, Polemonium humile, Echinospermum Redowskii etc.

The following shrubs relieve the monotony of tbe coniferous forest along the banks of streams: Viburnum pauciflorum, Sorbus (Pyrus) sambucifolia, with such herbs as Thalictrum dioicum, Epilobium laetiflorum, Heracleum lanatum var. vestitum.

On Baranof Island, near Sitka, the mountain hemlock *Tsuga Pattoniana* (= *T. Mertensiana*) found at high altitudes in the coast mountains descends nearly to sea level. — The forests at the head of Lynn Canal, a deep fiord of the coast (see plate XIV at page 587) differ somewhat from that nearer the coast. *Pinus contorta* of the coast passes on the interior plateau into the closely related species, the lodge pole pine *Pinus Murrayana* of the northern Rocky Mountains. *Betula kenaica* is very common at low elevations, and growing with it is *Acer glabrum*. Passing from the humid coast region to the dry interior an entirely different forest is entered. The coast hemlock, *Tsuga Mertensiana* (= *T. heterophylla*) and *Picea sitchensis* have disappeared and the largest tree in scattered groves about Lake Bennett and Lake Lindeman is *Abies subalpina* (= *A. lasiocarpa*) mingled with *Populus balsamifera* and *Picea alba* (= *P. canadensis*).

Occasionally the lowland forest extends up over the morainecovered bluff of ice and thence inland on the surface of the glaciers about Mt. St. Elias a distance of 4 or 5 miles. The face of the bluff is so completely covered with boulders, earth and vegetation, that it is seldom one has so much as a glimpse of the ice beneath[2]). Alders form the principally growth, reaching a height of 20 or 30 feet, but on the outer or older portion of the moraine (see plate XIV), there are dense groves of Picea sitchensis, some trees three feet in diameter, with a dense undergrowth of Fatsia (Echinopanax) horrida, salmonberry bushes, huckleberries and a species of Asplenium.

The vegetation of this region noted for its luxuriance is probably nowhere more highly developed than in the Queen Charlotte Islands[3]). Seven species of coniferous trees are found, namely, *Picea sitchensis* (dominant), the

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1) OSGOOD, WILFRED H.: Natural History of the Cook Inlet Region Alaska, North American Fauna 21 (1901): 53.

2) TARR, RALPH S.: The National Geographic Magazine XXI: 1—54. Jan. 1910, especially the pictures which show the forest in relation to glaciers.

3) OSGOOD, WILFRED H.: Natural History of Queen Charlotte Islands. British Columbia.

coast hemlock, *Tsuga Mertensiana*, the mountain hemlock, *Tsuga Pattoniana* (at 2,000 feet), *Thuja gigantea, Chamaecyparis nootkatensis, Pinus contorta* and *Taxus brevifolia.* Three trees are rather rare: *Thuja, Chamaecyparis* and *Pinus.* The forest, therefore, is essentially like that of the mainland previously described.

As one tree practically is dominant throughout the entire region, the forest may be said to form a single uniform formation in which the undergrowth is practically the same throughout. The herbs are Spiranthes decipiens, Streptopus, Tiarella trifoliata, Coptis asplenifolia, Pirola (5 spec.) and Monotropa, the shrubs and undershrubs, Gaultheria shallon, Menziesia ferruginea, Vaccinium ovalifolium, Cornus occidentalis, Rubus spectabilis, Fatsia horrida, Berberis repens (= B. aquifolium), Lonicera involucrata, Ribes bracteosum and laxiflorum occur in the denser portions, while Alnus rubra, Salix Barclayi, Sambucus racemosa, Viburnum pauciflorum occur at the margins, or in the open glades. Remarkable smaller plants of this forest formation are Cornus canadensis, Trientalis arctica, Coptis trifolia, Moneses uniflora, Aquilegia formosa, Ranunculus orthorhynchus, Viola sarmentosa (= V. sempervirens), Claytonia sarmentosa, Clintonia uniflora, Geranium erianthum, Dodecatheon Meadia, Rosa nutkana (wood borders) and gymnocarpa (climbing), Fragaria chiloënsis. — On the banks of small streams are found Saxifraga punctata, S. stellaris, S. Mertensiana, Mimulus Langsdorfii, Heuchera glabra and Claytonia sibirica. Scattered through the forest are open treeless spots, the larger of which are swampy where grow Lysichiton kamtschatcensis, Menyanthes, Athyrium filix-foemina. In the drier glades grow such grasses as Deschampsia caespitosa, Hierochloë odorata with Fritillaria kamtschatcensis.

### 3. Meadows, Helophytic and Psychrophytic Formations.

*Meadow Formation.* The only extensive grass lands in southeastern Alaska are those in the river valleys near the coast south of Yakutat, covering an old glacial moraine composed of a fine gravel which slopes gently to the seashore, while along the lower Ankau occurs a strip of several hundred acres well grassed with *Deschampsia caespitosa* and *Elymus mollis*, while along the river banks is a fine growth of *Calamagrostis*, *Langsdorfi* and *Carex cryptocarpa.* In general this formation consists of the grasses *Deschampsia* (*Aira*) *caespitosa*, *Poa pratensis*, *Agrostis canina*, *Calamagrostis neglecta*, *Carex echinata.* Adjoined grow *Fritillaria kamtschatcensis, Iris versicolor* and *sibirica*, orchids *Spiranthes* and *Habenaria*, *Rumex salicifolius, Ranunculus. Aquilegia formosa*, *Parnassia*, *Poterium Sanguisorba*, *Archangelica Gmelini*, *Dodecatheon*, *Collinsia*, *Boschniakia glabra*, *Pinguicula*, *Arnica cordifolia* and *Prenanthes alata.*

*Swamp and Pond Formation.* In the swamps are present *Glyceria pauciflora*, *Carex gynocrates (= C. Redowskyana), Tofieldia borealis, Stellaria (Alsine) borealis*, *Caltha palustris* var. *sibirica*, *Comarum*, *Hippuris*, *Cicuta* and *Myrica gale.* — *Menyanthes trifoliata* and *Nuphar polysepalum* grow in shallow ponds that are found in some of these opens. The algae of such fresh water ponds [1]) are numerous.

1 SAUNDERS, DE ALTON: The algae of the Expedition. Harriman Alaska Expedition. V. Cryptogamic Botany 1904: 155—211.

*Alpine Formation.* Above timber line on all of the Alaskan mountains the barren slopes are characterized by the presence of numerous alpine plants, frequently occuring in mats.

The mountains of the St. Elias Range in the Disenchantment Bay country are clothed to an altitude of about 800 feet with a dense growth of Alnus rubra above which the mountain sides are covered with a heavy growth of Deschampsia caespitosa var. longiflora to an altitude of 2,550 feet associated with Aconitum delphinifolium. Above the grass limit, the vegetation is more scattering and consists mostly of Salix arctica, Saxifraga bronchialis, Geranium erianthum, Cassiope Stelleriana, Eriogynia pectinata and Bryanthus glanduliflorus. In this treeless region, there grow besides the plants mentioned above: Agrostis exarata, Phleum alpinum and Poa alpina[1]), Tellima grandiflora, Arabis lyrata, Cerastium alpinum, Valeriana sitchensis, Potentilla procumbens, P. villosa, Parnassia fimbriata, Artemisia norvegica (very rare), Antennaria alpina, Campanula *rotundifolia* var. *alaskana*, *Petasites frigida*, *Hieracium triste*, Arnica latifolia, Romanzoffia sitchensis, Lycopodium alpinum, Cryptogramme acrostichoides, Cystopteris fragilis. Elsewhere grow Silene acaulis, Anemone Richardsonii, A. narcissiflora, A. parviflora, Mitella pentandra, Carex pyrenaica, C. nigricans, C. macrochaeta, Luzula spicata, L. parviflora, L. arcuata, Habenaria unalaschensis, H. dilatata etc.

*Fjelde Formation*[2]). About the upper border of the region of dwarf timber at 1,050 m are frequently found in the Sitkan Region extensive stretches covered with willows and dwarf birches with bare rocks, moss and lichen tundra, interspersed with snow field. This is a formation which on account of its similarity to a corresponding one in Norway is best designated as Fjelde or Fell Field.

Betula glandulosa var. rotundifolia, Alnus viridis (= A. alnobetula), Salix fulcrata, S. arctica var. Pallasii, Juniperus communis var. nana are prominent woody plants. Empetrum nigrum, however, is the most abundant species associated with the Ericaceae: Bryanthus glanduliflorus, B. empetriformis, Bryanthus (Phyllodoce) taxifolius, Cassiope Stelleriana, C. lycopodioides, C. Mertensiana, C. tetragona, Andromeda polifolia, Kalmia glauca var. microphylla, Arctostaphylos (Arctous) alpina, Vaccinium caespitosum, V. uliginosum, V. vitis-idaea, V. Oxycoccus. Between these plants grow Linnaea and Dryas, Diapensia, Silene acaulis in mats. Among the surrounding lichens and mosses, the botanist finds many arctic phanerogamae, Dodecatheon, Primula angustifolia, P. sibirica, Androsace septentrionalis, Eriogynia (Lütkea) pectinata, and in springy places Rubus chamaemorus. All of these plants are related to those of the alpine regions of the Rocky Mountains and the Sierra Nevada Mountains as described in Part III, Chapter 3.

## 2. Columbian Region.

This region comprises the plains of Puget Sound, the Columbia River, the main valley of the Fraser River, the lake county of northern Idaho and includes the Olympic Coast and Cascade Mountain ranges. It is a region noted for the density of its forests consisting of a large number of species which reach giant proportions. In fact this forest is the densest in North America, with exception of the redwood forests of northwest California.

1) FUNSTON loc. cit. p. 332; ENGLER, A.: Die pflanzengeographische Gliederung Nordamerikas: 58.

2) ENGLER loc. cit. p. 59; WARMING, Oecology of Plants, 256; also cf. HARVEY, LEROY H.: The floristic Composition of the vascular Flora of Mount Ktaadn, Maine. Mich. Acad. Sci. 1909: 32—47.

In this great coniferous forest, the trunks of trees two or three hundred feet in height are often only separated, according to my observations, by the space of a few feet. The ground shaded throughout the year by the impenetrable canopy of forest, never becomes dry; it is densely covered by a thick carpet of mosses, ferns (see Fig. 6, p. 265) and other plants. The more open portions are choked by an impenetrable growth of undershrubs. The soil which has produced the maximum growth of forest in this region is, outside the river bottoms, a thin porous gravel of glacial origin, rarely more than a few inches deep. The luxuriance of tree growth, therefore, illustrates the influence of a heavy rainfall and temperate climate upon the forest.

## A. Puget Sound—Cascade District.

This district comprises all of the flat sound country dominated by characteristic groups of plants, including the mountainous country, of the Cascade Mountains.

1. Before describing the forests a few remarks are necessary upon the Beach-, Salt Marsh- and the Marine Algal-Formation. — This coast is characterized by forms like Dictyoneuron, Postelsia, Laminaria Sinclairii, L. Andersonii and Fucus Harveyanus. The tide-pool vegetation of Port Renfrew, Vancouver Island, is distributed as follows:

High-tide pools. Corallina aculeata, Codium mucronatum, Phyllospadix Scouleri, Amphiroa cretacea, Cheilosporum planiusculum. Phyllospadix Scouleri (see Fig. 11 on p. 314) occurs in great abundance over the jagged sandstone rocks exposed only at low tide and in most of the numerous tide pools along the shore. Mixed with species of algae it forms a shelf which varies in width with the slant of the shore and the depth of the water, as it grows nowhere in very deep water. Zostera marina is found in the sheltered coves of the inner San Juan Harbor of Puget Sound and in these places it grows from a muddy, or sandy bottom, while epiphytic upon it is Porphyra naiadum.

Mid-tide pools. Species of Amphiroa, Codium, Corallina, Cheilosporum californicum and frondescens, Rhodomela larix, Soranthera ulvoides, Laminaria Cloustoni and bullata, Microcladia borealis, Endocladia muricata, Halosaccion hydrophora.

Low-tide pools. Laminaria and Alaria sp., Iridaea sp., Lessoniopsis littoralis, Corallina vancouveriensis. Nereocystis Luetkeana with its long stem readily adjusts itself to the depth of the water. Clinging to this are Ulva laetuca, Enteromorpha intestinalis, E. linza. The various surge and surf plants such as Lessoniopsis, Laminaria, Hedophyllum and Costaria occur only in limited numbers in the low tide pools[1].

Sand Beach Formation. Along the front border of the large open beaches as on the southwest shore of Vancouver Island, occur Juncus Lescurii, Arenaria major, Potentilla anserina var. grandis, Trifolium heterodon. Farther back on the middle or drift wood beach grow Elymus mollis, Festuca Jonesii, Bromus and many herbs. The upper beach in some places is characterized by Aira caryophyllea, Deschampsia caespitosa, Carex macrocephala and Artemisia Suksdorfii. Upon the small sand beaches at the mouths of ravines, it is difficult to differentiate between the lower and the upper beaches. No one species preponderates.

The Salt Marsh Formation is found on low shores near the mouths of streams where they are occasionally covered by high tides. The most characteristic plants are Distichlis spicata, Salicornia ambigua, Arenaria peploides, Atriplex littoralis, Carex cryptocarpa etc.

1) SKINNER, S. A.: Observations on the tide pool Vegetation of Port Renfrew, Minnesota Botanical Studies, 3. ser. Part II, 1903: 145.

The Rock Beach Formation of the Washington coast is subjected to the dashing ocean spray and occasionally to inundation by high waves. They are also exposed to strong winds. Here grow, according to ROSENDAHL[1]) Plantago maritima and major var. asiatica, Hordeum boreale (growing in tufts in rock crevices), Festuca rubra var. baikalensis and Agrostis exarata.

*Salal Formation.* Between the beach formation and the coniferous forest formation on Vancouver Island is a thicket composed of the salal, Gaultheria Shallon, which grows in great uniformity and continuity. Along the edge of the thicket and shaded by the salal branches grow Carex Deweyana, Linnaea borealis, Trientalis europaea var. arctica, Boykinia elata. In the dense growth of the salal occur Epilobium glandulosum, Elymus glaucus, Vicia gigantea, Sanicula Menziesii, while Boschniakia strobilacea is parasitic upon its roots. The shrubs that enter this formation are Rosa nutkana, Rubus (3 spec.), Lonicera involucrata, Pirus (Malus) rivularis, Amelanchier alnifolia, and stunted forms of Pinus contorta.

## 2. Coniferous Forest Formation.

As remarked before, this district is covered with the heaviest continuous forest in North America. This forest extends over the slopes of the Cascade ranges and occupies the entire drift plain surrounding the waters of Puget Sound, as well, as the western part of Oregon (see Fig. 6, Coniferous Forest along Columbia River, p. 265). The highest mountain peaks and the sand dunes of the coast are treeless. The most generally distributed tree is the red, or yellow fir *Pseudotsuga Douglasii* (= *P. taxifolia* = *P. mucronata)* forming about seven eighths of the forest growth. *Thuja gigantea* (= *T. plicata)*, the coast hemlock *Tsuga Mertensiana* often covering extensive tracts, are common. *Picea sitchensis* is of importance in the forests bordering the coast. *Abies amabilis* covers the upper ridges of the Cascade Mountains with *Abies nobilis* and *Picea Engelmanni*; south of Coos Bay, *Chamaecyparis Lawsoniana* mixed with *Pseudotsuga* and *Picea* occurs. — East of the Cascade Mountains the forests are less dense and are confined to the mountain ranges. The great plains watered by the Columbia and Snake rivers are entirely destitute of tree covering and their flora has been treated with the flora of the Great Basin (see ante page 567).

Northwest of the great bend of the Columbia River in northeastern Washington the forest is of open character composed principally of *Pseudotsuga Douglasii*, *Pinus ponderosa*, *Pinus monticola* and *Larix occidentalis*, as well, as *Populus balsamifera*, *Betula papyrifera*. The valleys of the Willamette, Umpqua and Rogue Rivers in Oregon contain an open scattered growth of *Quercus Garryana* and here *Pinus Lambertiana* with *Quercus (Pasania) densiflora* of the California flora mingle so that Rogue River may be taken as the approximate southern boundary of the Columbian Region, its northern boundary being marked by the northern limit of *Pseudotsuga Douglasii*.

Other trees of this forest may be mentioned: Abies subalpina (A. lasiocarpa), Pinus albicaulis, Larix Lyalli occur only at high elevations. Pinus Murrayana occurs sparingly toward the east. Taxus brevifolia is a common tree on moist land up to an altitude of 3,000 feet. Populus trichocarpa, P. balsamifera, P. tremuloides, Acer macrophyllum, Alnus oregona, Rhamnus Purshiana,

1) POSTELSIA 1906: 25.

Fraxinus oregona, Pirus (Malus) rivularis occur along streams at lower elevations. Acer circinatum is a large shrub or small tree common below 3,000 feet. Cornus Nuttallii, Prunus emarginata, Spiraea Douglasii, S. (Holodiscus) discolor, Philadelphus californicus and Viburnum ellipticum are elements of this forest.

Above 4,000 feet the height of the trees becomes perceptibly shorter and the stem more branched, the trunks more twisted. Above 6,000 feet the trees grow in groups or singly, leaving the principal areas treeless. These areas, when not too long covered by snow, are occupied by a large assemblage of species.

The forest of Vancouver Island[1]) is of a mountainous type. Pseudotsuga Douglasii is the chief tree until an elevation of 800 feet is reached. Here it mingles with Pinus monticola, Thuja gigantea and the chief undergrowth consists of Pteris aquilina var. lanuginosa, Gaultheria Shallon with Boschniakia Hookeri parasitic upon its roots. Higher still is found the coast hemlock, Tsuga Mertensiana (see adnotation p. 547) as the summit of the mountains is reached the mountain hemlock Tsuga Pattoniana and Abies amabilis appear. The coast species never found in the mountains are Abies grandis, Picea sitchensis the most abundant tree, Taxus brevifolia and Juniperus virginiana. Pinus contorta in places overhangs the sea, in other places it occurs in hogs. Quercus Garryana grows in situations where the forest is less dense. Arbutus Menziesii occurs on the east coast of the island, while Cornus Nuttallii is also a prominent feature in the landscape. In the low ground grow Acer macrophyllum, A. circinatum, Alnus rubra, Populus tremuloides, P. balsamifera, while bordering ponds are found Prunus mollis, Rhamnus Purshii. The undergrowth consists of Rubus nutkanus, Nuttallia (Osmaronia) cerasiformis, Prunus emarginata, Vaccinium caespitosum, V. angustifolium, Gaultheria Shallon, Berberis repens (= B. aquifolium), B. nervosa and Pachystima myrsinites, together with such herbs and ferns as Blechnum spicant, Nephrodium (Polystichum) munitum, Dryopteris spinulosa (along streams), Streptopus amplexicaulis, Listera cordata, Lysichiton kamtschatcense, Tiarella trifoliata and Boykinia elata.

The following belts may be recognized at 45° 30′ north latitude in the basins of the streams tributary to the Columbia River where it cuts through the Cascade Range.

Belt of Pinus ponderosa (below 3,000 feet). This belt consists of *Pinus ponderosa, Pseudotsuga Douglasii, Abies grandis, Thuja gigantea* to which if the latitude is 47° 30′ should be added the coast hemlock *Tsuga Mertensiana.*

Belt of Pinus Murrayana (3,000—5,000 feet). This belt consists of *Pinus Murrayana, P. monticola, Picea Engelmanni* and *Taxus brevifolia* with the following additional species in latitude 47° 30′: *Abies nobilis, A. amabilis, Larix occidentalis, Chamaecyparis nootkatensis.*

Belt of Abies subalpina (5,000—6,000 feet). Here grow *Abies subalpina* (= *A. lasiocarpa*), *A. amabilis, A. nobilis,* the coast hemlock *Tsuga Mertensiana, Chamaecyparis nootkatensis* and *Larix occidentalis,* while in latitude 47° 30″ only two trees *Abies subalpina* and the mountain hemlock *Tsuga Pattoniana* occupy it.

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1) Macoun, John: List of herbaceous plants in flower in May on Vancouver Island. Forests of Vancouver Island, see Bibliography p. 54—55.

Belt of Pinus albicaulis (6,000—7,000 feet or to timber line). *Pinus albicaulis*, *Tsuga Pattoniana*, *Larix Lyallii* and *Juniperus nana* are found in this belt, but in latitude 47° 30′ *Tsuga Pattoniana* is absent.

The forest about Mount Tacoma (Rainier [46° 40′ n. L.]) consists of Pseudotsuga Douglasii, which ranges from sea level to 5,600 feet with a diameter from 6—9 feet; the coast hemlock, Tsuga Mertensiana ranging from sea level to 5,000 feet, with an extreme diameter of 6 feet and a height of 250 feet; Pinus monticola (0—6,000 feet, diameter 5 feet, height 150 feet); Pinus ponderosa grows between 400 and 6,200 feet, with an extreme diameter of 6 feet and a height of 200 feet; Pinus Murrayana ranging from 1,800 to 7,000 feet attaining its maximum growth above 4,000 feet. Abies nobilis is found between altitudes of 1,800 and 5,200 feet with a diameter of 6 feet and a height of 225 feet. Abies amabilis (800—5,500 feet), A. concolor (0—4,200 feet), Picea Engelmanni (1,000—6,200 feet), P. sitchensis (0—1,800 feet), Thuja gigantea (0—5,100 with extreme diameter of 12 feet and height of 175 feet), Chamaecyparis nootkatensis (2,600—7,400 feet), Larix occidentalis (2,200—5,600 feet), Taxus brevifolia (0—4,200 feet), are prominent elements of this forest, while Pinus albicaulis (5,000—8,200 feet), Abies subalpina (A. lasiocarpa (4,000—7,500 feet) the mountain hemlock Tsuga Pattoniana (3,500—7,500 feet and Larix Lyallii (north of Mt. Rainier) may be called alpine trees. The deciduous trees of the Mount Tacoma forest are Fraxinus oregona, Populus tremuloides, P. trichocarpa and Quercus Garryana.

To sum up, at an elevation of 4,000 feet, or more, the flanks of Mount Tacoma (Rainier) are clothed with a continuous belt of somber forest, discontinuous only where glaciers and glacial streams have broken the continuity. This forest consists of *Pseudotsuga, Abies amabilis, Pinus monticola, Tsuga Mertensiana, Picea Engelmanni* (a few). About 3,500 feet the character of this forest changes: the mountain hemlock *Tsuga Pattoniana* replaces the coast hemlock; *Abies nobilis* replaces *Pseudotsuga*. At 4,500 *Abies subalpina* appears and the forest from this point upward consists of the mountain hemlock *Tsuga Pattoniana*, *Chamaecyparis nootkatensis*, *Abies subalpina*, *Pinus albicaulis* confined to the crests of ridges. At 6,500 feet elevation the timber ceases. Scraggly firs and hemlocks more or less prostrate are found. Here too the continuous carpet of grasses and flowers stops.

The undergrowth consists of:

Salix fluviatilis Nutt.
» sitchensis Sanson [1]).
Alnus viridis DC. (= A. alnobetula Ehrh. (north of Rainier).
» Oregona Nutt.
Berberis nervosa Pursh.
» repens Lindl. (= B. aquifolium Pursh).
Pachystima myrsinites Raf.
Rhamnus Purshiana DC.
Ceanothus velutinus Dougl.
» sanguineus Pursh.
Acer circinatum Pursh.
» glabrum Torr.
Prunus emarginata var. mollis Brewer, (= P. villosa Sudw.).

1) See PLUMMER, F. G.: Bibl. p. 81, and: Forest Condition in the Cascade Range, Washington, between the Washington and the Rainier forest Reserves, U. S. Geological Survey, Professional paper 6, Series, H. Forestry 3, 1902; COVILLE, F. V.: The August Vegetation of Mount Mazama, Oregon. Mazama I: 170—203. May 1897.

Prunus demissa Walp.
Rosa gymnocarpa Nutt.
» Nutkana Presl.
» californica Cham. et Schlecht.
Spiraea Douglasii Hook.
» (Holodiscus) discolor Pursh.
» corymbosa Raf.
Sorbus (Pirus) sambucifolia Cham. et Schlecht.
Pyrus (Malus) rivularis Dougl.
Amelanchier alnifolia Nutt.
Rubus nutkanus Moc. (= R. parviflorus Nutt.).
» spectabilis Pursh.
» leucodermis Dougl.
» ursinus Cham. et Schlecht.
» pedatus Smith.
» lasiococcus A. Gray.
Purshia (Kunzia) tridentata DC.
Neillia (Opulaster) opulifolia L.
Philadelphus Lewisii Pursh.
Crataegus macracantha Lindl. (North of Rainier).
Ribes sanguineum Pursh.
» bracteosum Dougl.
» viscosissimum Pursh.
» cereum Dougl.
» ciliosum Howell.
» lacustre var. molle A. Gray.
» divaricatum Dougl.
Fatsia (Echinopanax) horrida B. et H.
Cornus canadensis L.
» Nuttallii Aud.
» pubescens Nutt. (= C. occidentalis T. et G.)
Sambucus melanocarpa A. Gray.
» racemosa Linn.
» glauca Nutt.
Viburnum pauciflorum Pylaie.
Symphoricarpus racemosus Michx.
Lonicera ciliosa Poir.
» involucrata Banks.
Vaccinium parvifolium Smith (= V. myrtilloides A. Gray var. membranaceum Dougl.
» myrtilloides Hook.
» myrtillus L. var. microphyllum Hook.
Arctostaphylos tomentosa Dougl.
» nevadensis A. Gray (North of Rainier).
Gaultheria ovatifolia A. Gray.
Kalmia glauca Ait. (= M. urceolaria Salisb.).
Menziesia ferruginea Smith (= M. urceolaria Salisb.).
Rhododendron albiflorum Hook. (= Azaleastrum albiflorum Hook.).
Here too occur several whitish or reddish saprophytes: Monotropa hypopitys, Pterospora andromedea and Corallorhiza Mertensiana.

The forest on the Cascade Mountains of southern Oregon, north of the Klamath Gap, which is a barrier of great antiquity and effectiveness in the distribution of plants [1]), is overwhelmingly coniferous. This is especially the case east of the Cascades, where broad-leaved species of trees form but a fraction of one per cent of the forest stands, and where two conifers, *Pinus ponderosa* and *P. Murrayana* together constitute 88 per cent. West of the Cascades broad-leaved trees occur more plentifully, forming about 6 per cent of the entire forest; and while among the conifers two species *Pinus ponderosa* and *Pseudotsuga* particularly predominate, there is also a wider range of ratios among the balance than is found on the eastern side of the range.

1) See ante page 256.

The coniferous trees in the Cascade Mountains of Oregon (see plate XV, page 600), especially in the neighborhood of Mount Hood (*marked)[1] are *Pinus ponderosa, *P. Lambertiana, *P. monticola, *P. albicaulis, *P. Murrayana, *Abies concolor, *A. amabilis, *A. nobilis, A. subalpina *Pseudotsuga Douglasii, Libocedrus decurrens, *Chamaecyparis nootkatensis, *Thuja plicata, *Tsuga Mertensiana, *Tsuga Pattoniana, *Picea Engelmanni, *Taxus brevifolia, Juniperus occidentalis, while the broad-leaved trees comprise *Quercus californica, Q. Garryana, Arbutus Menziesii, Fraxinus oregona, *Acer macrophyllum, *Alnus oregona, Cercocarpus ledifolius, C. betuloides, *Castanopsis chrysophylla, Pirus (Malus) rivularis, *Populus tremuloides, P. balsamifera, P. trichocarpa and Sambucus glauca. The northern limit of Pinus Lambertiana is 44° 47′ latitude on the western slopes. The southern limit of Chamaecyparis nootkatensis is Deer Creek a tributary of the Mackenzie River, while Larix occidentalis attains its northern limit at 44° 08′ north latitude.

The altitudinal distribution of the trees mentioned is shown in the accompanying table.

| | West of Cascades. | East of Cascades. |
|---|---|---|
| Pinus ponderosa | 1,800—6,000 feet | 4,000—7,000 feet |
| » Lambertiana | 3,000—5,000 » | 4,800—6,000 » |
| » monticola | 5,000—7,500 » | 5,500—6,000 » |
| » albicaulis | 6,000—9,300 » timber line. | 6,000—9,300 » |
| » Murrayana | 3,000—8,000 » | 4,200—8,500 » |
| Pseudotsuga Douglasii | 2,500—6,800 » | 4,300—7,000 » |
| Abies concolor | 3,000—6,000 » | 4,000—7,500 » |
| » nobilis | 5,200—8,800 » | 6,000—8,800 » |
| » subalpina | 5,880—7,800 » | 5,880—7,800 » |
| Tsuga Mertensiana | 5,200—6,000 » | |
| » Pattoniana | 6,000—9,200 » Close to timber line. | 6,000—9,200 » |
| Libocedrus decurrens | 2,500—5,000 feet | 5,000—6,600 » |
| Picea Engelmanni | 5,800—8,000 » | 5,600—8,000 » |
| *Juniperus occidentalis* | *1,600—5,200* » | *Lowest elevations* to 6,000 feet. |

Several facies, or types, are recognizable in this forest formation. As complete data is lacking for each, only the general details of their composition can be given.

*Pinus ponderosa Belt. As to annual precipitation and mean ratio of soil humidity, this* facies occupies the lowest position. It is the dominant type throughout the upper Klamath Basin, but on the western side of the Cascades it is not well developed. It is rarely pure, but Abies concolor, Pseudotsuga Douglasii, Libocedrus decurrens, Pinus Lambertiana and P. Murrayana are associated with the yellow pine, and an undergrowth of Purshia tridentata, Ceanothus velutinus, Arctostaphylos patula and Castanopsis chrysophylla var. minor[2]. It is more of a southern type of forest. Frequently Pinus Murrayana forms almost pure stands, in two aspects; first, in the "contorta" form of the species found along the edges of marshes, creeks or springy localities; secondly, in the "Murrayana" form found as straight slender trees on well drained uplands.

1) Leiberg, John B.: Cascade Range forest Reserve. 21st Report U. S. Geological Survey Part V. 209—497; Langille, H. H., Plummer, F. G. et al. Forest Conditions in the Cascade Range forest Reserve Oregon, U. S. Geological Survey, Professional Paper No. 9. Series H. Forestry 6; Sudworth, George B.: Forest Trees of the Pacific Slope. U. S. Forest Service 1908.

2) Coville, F. V.: Forest growth and sheep grazing in the Cascade Mountains of Oregon. U. S. Division of Forestry, Bulletin 15: 19, 1898.

Pseudotsuga Douglasii Belt. This type occupies areas situated at higher elevations than those of the yellow-pine type, hence these areas have considerably greater precipitation and soil humidity. On the western side of the Cascades it is the dominant type. It is never a pure type but Pinus ponderosa, P. Lambertiana, P. monticola, P. Murrayana, with an open undergrowth of Arctostaphylos nevadensis, Ribes cereum, Abies concolor, A. nobilis, coast hemlock Tsuga Mertensiana, Picea Engelmanni and Taxus brevifolia are mixed with it. Several types of this forest are recognizable where Abies concolor, or Pinus ponderosa, or Pinus Murrayana, or Pinus monticola, or Abies nobilis becomes the chief components.

Tsuga Pattoniana Belt. The subalpine belt which lies above 6,200 feet on the western slopes of the Cascade Mountains and 6,500 feet on the eastern is covered with forests of the alpine hemlock type. On small areas this forest is a pure growth of Tsuga Pattoniana (= T. Mertensiana) with an undergrowth of Vaccinium scoparium and V. membranaceum, elsewhere Pinus Murrayana, P. monticola, P. albicaulis, Abies nobilis, A. subalpina (A. lasiocarpa and Picea Engelmanni occur with Tsuga Pattoniana). The highest limits for the alpine-hemlock type are the timber lines, varying from 8,000 feet on northern slopes of the highest peaks to 9,500 feet on southern declivites.

Along the edge of extreme timber line Tsuga Pattoniana is wanting and Pinus albicaulis reigns supreme. The following examples taken from the southern declivities of Mount Pitt in Oregon are illustrative [1].

| | | | |
|---|---|---|---|
| Timber line . . . . . . . Pinus albicaulis . . . . . | 100 per cent | 800 feet below timber line: | |
| 300 feet below timber line: | | Pinus albicaulis . . . . . . . | 2 per cent |
| Pinus albicaulis . . . . . . . | 50 » » | Tsuga Pattoniana (= T. Mertensiana) . . . . . . . . . . | 88 » » |
| Tsuga Pattoniana (= T. Mertensiana) . . . . . . . . . | 50 » » | Abies nobilis . . . . . . . . . | 10 » » |

## 3. Prairie-, Meadow- and Alpine Formations.

*Gravelly Prairie Formation.* Existing as islands in the red fir forests, which are unable to encroach because the gravelly prairie soil serves as an almost perfect barrier to this tree, are the prairies which present the appearance of a sterile pasture with scattered oaks (*Quercus Garryana* here and there). Until the middle of July these prairies are carpeted with flowers after which they assume an arid appearance.

*Sage Formation.* This represents an extension of the Great Basin flora into the middle valley of the Fraser River in British Columbia. Where Jackass Mountain intercepts whatever little moisture comes up the valley of that river is an area where Artemisia tridentata becomes frequent.

Associated with it are Artemisia frigida, Bigelovia (Chrysothamnus = Linosyris) graveolens, Plantago patagonica, Crepis occidentalis, C. occidentalis var. nevadensis, Antennaria alpina, A. dimorpha, Myosurus aristatus, Phacelia circinata (= P. heterophylla), P. Menziesii (= P. linearis), Oxytropis campestris, Astragalus Beckwithii, A. pilifolia, Lithospermum pilosum, Chrysopsis hispida and Arnica foliosa [2].

*Pumice Field Formation.* About Crater Lake the gentle outer slopes consist of pulverized pumice without any admixture of humus. The vegetation

1) LEIBERG, JOHN B.: Loc. cit. page 261.

2) MACOUN, JOHN: Geological and Natural History Survey of Canada, Reports of Progress, 1875—76: 121.

consists of herbaceous plants such as *Polygonum shastense* and *Newberryi*, *Phlox Douglasii*, *Spraguea*, *Arenaria pumicola*, *Arabis platysperma* and *Eriogonum pyrolaefolium*. — On Mount Tacoma (Rainier) the pumice fields are found above the limit of trees and they range from 6,500 feet to 10,000 feet. They are best developed on the east side of the mountain where the avalanches have covered great areas with more or less finely divided basalt. The conspicuous plants are *Lupinus Lyallii*, *Spraguea*, *Polemonium elegans*, *Aster pulchellus*, *Hulsea nana*, *Erigeron aureus*, *Polygonum Newberryi*, *Poa Suksdorfii*, *Draba aureola* and *Smelowskia ovalis*. The last three ascend to an altitude of 10,000 feet[1]).

*Meadow Formation*. Where springs break out, as for example at Crater Lake in southern Oregon, little mountain meadows are formed, the vegetation of which consists of a dense turf of grasses and sedges interspersed with *Pedicularis groenlandica*, *Dodecatheon alpinum*, *Kalmia glauca*, *Polygonum bistortoides*, *Tofieldia occidentalis*, *Gaultheria myrsinites* and *Vaccinium caespitosum*. The vegetation along the precipitous water courses and in the narrow shaded ravines is somewhat similar to that of the meadows and is often more or less mixed with it. The more striking plants of such localities are *Mimulus Lewisii*, *Veratrum viride*, *Habenaria gracilis*, *Aconitum columbianum*, *Viola glabella* and *Veronica alpina* (= *V. Wormskjoldii*). Paradise Valley on the south flank of Mount Tacoma (Rainier) is a large mountain meadow celebrated for its flowers, as are also similar mountain parks.

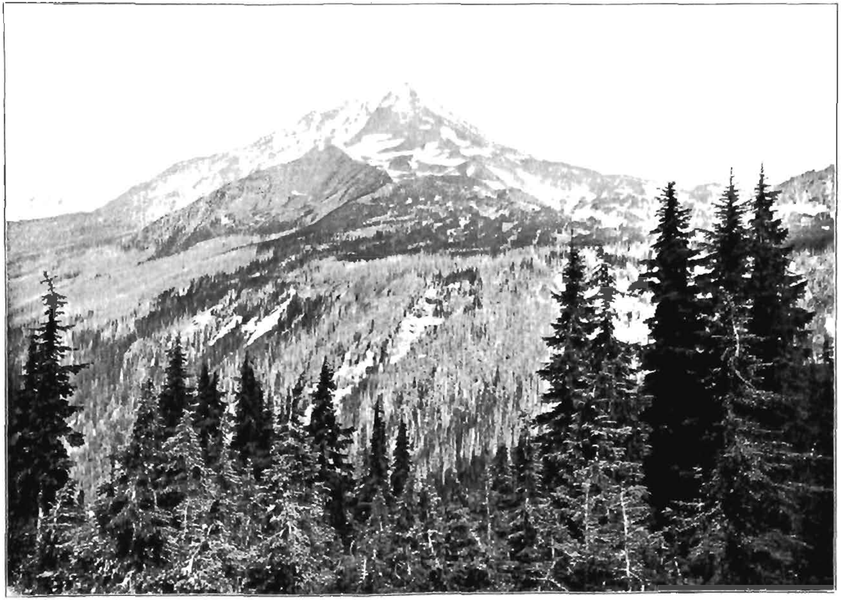
*Bog Formation*. Sphagnum bogs, according to PIPER, are quite common throughout western Washington. In them grow such plants as *Ledum latifolium*, *Kalmia glauca*, *Salix myrtilloides*, *Myrica gale*, *Betula glandulosa* and the herbs *Drosera rotundifolia*, *Eriophorum russeolum*, *Scheuchzeria palustris* and *Juncus oregona*. On the drier hummocks *Tsuga Mertensiana* (= *heterophylla*) occurs, and in the bogs near the sea coast *Ledum columbianum* and *Myrica californica* replace their two close relatives. Throughout the forest on Vancouver Island bogs also occur and lakes of considerable size are found, the largest of which is Cowichan, over 20 miles long, showing several circum-areas of vegetation, according to ROSENDAHL.

*Alpine Formation*. Although the phytogeographic district under consideration includes such mountain peaks as Mount Adams (12,470 feet), Mount Baker (10,827 feet), Mount Tacoma (Rainier) (14,526 feet), Mount Saint Helens (10,000 feet), Mount Hood (11,225 feet), Mount Jefferson (see plate XV) and Mount Pitt (9,760 feet), yet the alpine flora of these mountains enumerated by PIPER[2]), comprises 156 species of plants.

Above timber line, which extends on all the northwestern mountains higher on the ridges than in the ravines between, the alpine flora on the highest

1) PIPER, C. V.: The Flora of Mount Rainier. Mazama II: 94. April 1901; COVILLE, F. V.: The August Vegetation of Mount Mazama, Oregon, Mazama I: 170—203.

2) PIPER, C. V.: The Flora of Mount Rainier. Mazama II: 94, April 1901. — The flora of Washington, p. 63—65.



**Coniferous Forest Formation on Mt. Jefferson.**

Cascade Mountains, Oregon. Light areas indicate burnt timber. Dark areas subalpine forest unburned. (See text p. 601 for component vegetation).

peaks extends up to 10,500 feet (3,200 meters) altitude. The lower portion of this belt, except where there are outcroppings, is covered with a dense carpet of grasses and flowering plants.

Among the more abundant of the former are Festuca viridula, Poa arctica and Agrostis Rossii. Among the conspicuous herbs in the damper places are Ranunculus Suksdorfii, Caltha leptosepala, Dodecatheon Jeffreyi. On the drier slopes Pulsatilla occidentalis raises its tosseled mass of akenes; Lupinus subalpinus forms great patches of blue; Castilleja oreopola makes carpets of dull crimson and Potentilla flabellifolia furnishes abundance of yellow color. Two "heathers" are conspicuous: Bryanthus (Phyllodoce) empetriformis with clusters of rose-purple flowers and Cassiope Mertensiana with clusters of pure white. Along the rills Gentiana calycosa and Mimulus Lewisii form bright colored borders. Saxifraga Tolmiei and Eriogynia (Lütkea) pectinata form dense mats.

In general above 2,400—2,500 meters grow Agrostis humilis, Festuca ovina var. brevifolia, Eriogonum pyrolaefolium, Carex atrata, Douglasia laevigata, Aster alpinus, A. pulchellus, Erigeron salsuginosus. Antennaria alpina and in moory places Betula glandulosa, Rubus arcticus, Polygonum viviparum and Salix arctica, while at about 3,000 meters are found Carex Breweri, C. pyrenaica and C. Nardina. At 10,000 feet on Mount Tacoma (Rainier) grows Smelowskia ovalis and far above this plant even to the rim of the crater lichens occur on the rocks, while on the steam-warmed rocks of the crater are two mosses Hypnum elegans and Philonotis fontana[1]). On the summit of Mount Scott (9,122 feet) are found Pentstemon Davidsonii, Polemonium pulchellum, Erigeron compositus, Eriophyllum lanatum, Oxyria digyna, Saxifraga Tolmiei, Cryptogramme acrostichoides, Carex Breweri, Potentilla glandulosa, Raillardella argentea, Anemone (Pulsatilla) occidentalis, Spraguea umbellata, Polygonum Newberryi, P. shastense, Lupinus minimus, Trisetum subspicatum and Juncus Parryi[2]).

According to COVILLE (loc. cit.) upon such rocky peaks as Watchman (8,125 feet) and Castle Crest occur a series of rupestrine plants conspicuous among which are Cryptogramme acrostichoides, Oxyria digyna, Pulsatilla occidentalis. Arabis Lyallii, Peucedanum Martindalei, Bryanthus (Phyllodoce) glanduliflorus, Pentstemon Davidsonii and Hieracium gracile.

## B. Olympic District.

This district includes the Olympic Mountains in northwest Washington and the Coast Mountains of Oregon. The Olympic Mountains culminate in Mount Olympus 8,200 feet in altitude. This district is hardly distinct phytogeographically from the Puget Sound-Cascade mountain district but it differs mainly in negative characteristics viz: (1) the absence of many trees such as *Pinus ponderosa*, *P. Murrayana*, *P. albicaulis*, the mountain hemlock *Tsuga Pattoniana*, *Picea Engelmanni*, etc.; (2) in its geographic isolation; (3) in the more uniform constitution of the forest[3]).

*Coniferous Forest Formation.* Taken as a whole this is the most heavily forested region of the northwest, extending in unbroken formation to the edge

1) PIPER, C. V.: The flora of Mount Rainier. Mazama II: 94, April 1901. — The flora of Washington, p. 63—65.

2) COVILLE, F. V.: The August Vegetation of Mount Mazama. Mazama I: 170—203.

3) The number of papers on the flora of the Olympics is extremely few. The writer is familiar with only three on its flora: DODWELL, ARTHUR and RIXON, THEODORE F.: Olympic forest Reserve. 21st Report U. S. Geological Survey, Part V: 145—208; HENDERSON, L. F.: Flora of the Olympics. Zoe, II: 253; CONARD, HENRY S.: The Olympic Peninsula of Washington. Science new ser. XXI: 392, March 10, 1905.

of salt marshes, sand dunes and sea beaches on the Pacific coast side of the district. The available timber per township runs from 3,000 feet B. M. (= board measure) amid the high mountains to 5,900 feet B. M. in the northwest corner. What with fallen timber and undergrowth of ferns and shrubs the forest is almost impenetrable. The principal trees of this forest are *Tsuga Mertensiana* (up to 4,500 feet), *Pseudotsuga Douglasii* with the exception of the area immediately bordering the Pacific Ocean, while it extends up the mountain slopes to an altitude of 3,500 feet. *Abies amabilis* (rarely below 1,500 feet), *Thuja gigantea* (low and swampy ground). *Chamaecyparis nootkatensis* (on ridges below 3,500 feet), *Pinus monticola* (about 500 feet on western slopes frequently in swamps) are important elements of the forest, while *Abies subalpina* (= *A. lasiocarpa*) is found only on the higher parts of the mountains and rarely below an elevation of 5,000 feet [1]). Below 5,000 feet is the great northwestern forest in which *Acer circinatum*, *A. macrophyllum* (bottom lands), *Arbutus Menziesii* and *Populus trichocarpa*, growing along streams and on the shores of small lakes, figures as the deciduous element of the forest.

The undergrowth consists of Alnus oregona, Cornus Nuttallii, Pirus (Malus) rivularis, Fatsia (Echinopanax) horrida and species of Rubus, Vaccinium and Ribes. The herbaceous plants of this forest are Monotropa uniflora, M. hypopitys, Boschniakia strobilacea, Pyrola aphylla, Corallorhiza Mertensiana, Listera convallarioides, L. cordata, Cornus canadensis, Clintonia uniflora, Nephrodium (Polystichum) filix mas and munitum (a fern of large size), Adiantum pedatum, Athyrium filix-foemina, Smilacina (Vagnera) racemosa, Allotropa virgata, Goodyera Menziesii, Luzula comosa, Trillium ovatum, Prosartes oregona (on borders of swamp) Lycopodium clavatum, Streptopus amplexifolius and Neillia opulifolia (in swamps). The herbs in the maple bottoms are Asarum caudatum, Tolmiea Menziesii, Mitella caulescens, Dicentra formosa, Hydrophyllum virginicum and the moss Mnium Menziesii.

Alpine Formation. Above tree limit, near snow banks, are found Xerophyllum tenax, Ranunculus Eschscholzii, Viola glabella, Erythronium revolutum, Taxus brevifolia, Prosartes oregona (= Disporum majus), Actaea arguta, Berberis nervosa, Ribes lacustre var. parvulum, Ribes laxiflorus, Valeriana sitchensis, Mitella trifida, M. Breweri, Menziesia glabella, Rhododendron (Azaleastrum) albiflorum, Fragaria chiloensis, Pedicularis bracteosa and Douglasia nivalis var. dentata. Clinging to overhanging rocks grow such herbs as Pentstemon Menziesii, Saxifraga occidentalis, S. punctata, Allium Tolmiei, Arabis hirsuta, Pachystima myrsinites, Bryanthus (Phyllodoce) empetriformis and Cassiope Mertensiana.

## 3. Californian Region.

The flora of a region with as highly diversified a topography and climate, as California, must be of a highly diverse character. The study that botanists have made of its vegetation shows that such is the case. The southern and southeastern portions of the region are arid in the extreme, and support a flora of a desert character; the western flanks of the Sierra Nevada Mountains bear a magnificent forest of coniferous trees, which reach giant proportions,

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1) See also DODWELL, ARTHUR and RIXON, THODORE F.: Forest Conditions in the Olympic Forest Reserve, Washington U. S. Geological Survey, Professional Papers No. 7, Series H. Forestry 4. 1902. p. 16.

while the height of the snow-capped mountains permits a boreal flora to exist in a region otherwise inimic to such plants; the interior valley of California also bears a unique vegetation and the coast range flora is quite distinct from that of any of the nearby phytogeographic districts. As a whole: this part of the Pacific Section makes an interesting transition between the northern wooded and the southern arid territories.

## A. Coast Range District.

This extends along the Coast of the Pacific Ocean from Rogue River and the Siskiyou Mountains (42° N. latitude) south to the latitude of Point Concepcion (34° 30′). Its continuity is broken in the neighborhood of San Francisco Bay, where the interior valley is entered by tidal sea water. We can, therefore, distinguish a northern (Mendocino) area and a southern (Santa Lucia) area. As we have made evident (see ante pages 271—275), the flora of the Coast ranges is interesting in possessing many elements. The true Coast range flora is endemic and much the oldest and most unique. It also lacks the northern genera which may be called boreal-alpine. The northern element from Oregon and Washington is practically coëxtensive with the redwood area; the herbaceous undergrowth in the redwood area being northern. The Sonoran element overlaps the southern portion of the Coast Range between San Francisco Bay and Tehachapi Pass. Such a flora merits more than a passing notice.

### a) Mendocino Area.

The Coast Range to the north of the Bay of San Francisco is a peculiarly dislocated complex of mountains. Nothwithstanding its heavy annual rainfall, the area has a period of drought from about the end of July until about the end of September, but during this period, according to the observations of the writer at Humboldt Bay, the forest is by no means dry, because dense fogs roll in from the Pacific and precipitate considerable moisture[1]). The limits of the sea fogs are just about the limits of *Sequoia* and the higher ridges in consequence above the fog level support only a scattering growth of redwood. In general, the distribution of the tree growth of the northern Coast Mountains is as follows:

(a) Immediately along the coast shore, and outside the redwoods, brush growths and a growth of coniferous trees of various kinds.

(b) The redwood strip, occupying the western slope of the outer backbone of the Coast Range.

(c) Following the redwoods, a separate development of trees, which are found in the redwood strip in conjunction with the redwood; strip of *Pseudotsuga Douglasii*, *Quercus (Pasania) densiflora*, *Castanopsis chrysophylla* etc.

1) See also CANNON, W. A.: On the Relation of Redwoods and Fog to the general Precipitation in the redwood Belt of California. Torreya, I: 137.

(d) Strips of open wooded lands dotted with oaks *Pinus ponderosa* and spruce.

(e) Strips of *Pinus Lambertiana*, *P. ponderosa*, *Pseudotsuga* etc.

(f) The slope to the Sacramento Valley; Strip of small pines and oaks[1]).

## 1. Coastal Formations.

*Dune Formation.* The principal sand dunes of the northwestern coast of California occur at the mouth of the Garcia River, at Point Arena, at Pudding Creek near Fort Bragg, at the mouth of Ten-mile River and according to my observations along Humboldt Bay, which is separated from the ocean by two narrow peninsulas of sand, the mouth partially closed by shifting bars.

The following plants are characteristic of the Californian sand dunes: *Abronia latifolia*, with heavy prostrate stems and flat leaves; *Arctostaphylos uva-ursi* in large mats on almost pure sand on the sand spit of Humboldt Bay: *Convolvulus soldanella*, *Festuca rubra* var., *Poa Douglasii*, *Tanacetum camphoratum*, *Elymus arenarius*, *Lupinus Chamissonis*, *L. arboreus* (south of Point Reyes), *Collinsia bartsiifolia* (in drift sand), *Corethrogyne californica* var. *obovata* and species of *Prunus*, *Juncus* and *Salix*[2]).

*Coast Bluff (Mesa) Formation.* The coast bluffs vary in width from one to three miles forming a mesa, or bench, between the shore line and the summit of the first mountain ridge, which is about 1,600 feet high. This ridge marks the western edge of the redwood strip. The coast bluffs are elevated about 50 feet, or more, above the sea, but at Humboldt Bay, according to my observations, it has been eroded almost to sea level, there forming a large and very fertile flood plain. It is subject to heavy summer fogs, enjoys a more equable summer climate and a greater amount of moisture, than is found in the interior and is relatively cool.

The poorer lands are characterized by growths of *Pinus muricata* and *P. contorta*, while in Humboldt and Del Norte counties these are replaced by *Abies grandis*, *Picea sitchensis* and coast hemlock *Tsuga Mertensiana*. Perennial grasses are abundant, such as *Danthonia californica*, *Festuca rubra*, *Calamagrostis aleutica*, *Deschampsia* spec. etc. in company with such maritime plants as *Erigeron glaucus*, *Mesembryanthemum aequilaterale*, *Lupinus Michenerii*.

*White Ash Plain Formation*[3]). On the ridges which separate the smaller coast streams, e. g. the Noyo and Albion Rivers, are found the white-ash prairies, or white plains. They do not cover the whole of a ridge, but predominate near its western extremity, where the sandstone outcrops and the soil is white and powdery almost impervious to water.

1) First Biennial Report, California State Board of Forestry 1885—86: 133.

2) DAVY, JOSEPH BURTT: Stock Ranges of northwestern California. U. S. Bureau of Plant Industry Bulletin 12: 56—62. 1902.

3) DAVY, J. BURTT: loc. cit. p. 52.

A distinctive flora characterizes these plains composed of Quercus (Pasania) densiflora, Pinus muricata, P. contorta, Cupressus Goveniana, Castanopsis chrysophylla, Gaultheria shallon, Vaccinium ovatum, Rhododendron californicum, Myrica californica, Ledum glandulosum, Arctostaphylos nummularia and such woody and herbaceous species as Polygala californica, Helianthemum scoparium, Xerophyllum tenax, Hypericum concinnum, Gentiana Menziesii, G. oregona, Lilium maritimum, Panicum unciphyllum (= P. dichotomum), Agrostis Pringlei and Lotus leucophaeus.

Bog Formation. Perhaps owing to the impervious nature of the soil, sphagnum, or peat bogs have formed in the low hollows on the plains. Here grow Ledum glandulosum (the prevailing species), Blechnum spicant, Gaultheria shallon, Myrica californica, Veratrum fimbriatum, Viola sarmentosa (= V. sempervirens), Trientalis latifolia, Sisyrinchium californicum, Hosackia gracilis (= Lotus formosissimus), Cornus canadensis, Hypericum anagalloides, Gentiana Menziesii, Drosera rotundifolia, Campanula linnaeifolia, Calamagrostis aleutica, C. Bolanderi, C. crassiglumis, species of Agrostis, Juncus, Carex. The bog mosses are three species of Sphagnum, S. cymbifolium, S. mendocinum and S. subsecundum var. longifolium.

Davy says with reference to the bluff flora. "An analysis of the flora as above listed shows that its most characteristic feature does not consist so much in the presence of endemic species as in the commingling of the adjacent redwood and coast floras, with the addition of species commonly found in thin soils at comparatively high altitude, and of certain peculiarly boreal species, rarely if ever found at other points in the Coast ranges, and when met with elsewhere in the State, usually occurring at very much higher altitudes. The phenomenal feature is, therefore, the occurrence of several species belonging to high altitudes and latitudes, along a narrow coast mesa not more than 200 feet above sea level, and between the thirty-ninth and fortieth degree of north latitude".

The species to make this clearer, may be classified as follows: Plants of dry ridges in the redwood strip are Cupressus Goveniana, Quercus densiflora, Polygala californica, Castanopsis chrysophylla, Xerophyllum tenax, Gaultheria shallon, Vaccinium ovatum, Hypericum concinnum, Helianthemum scoparium, Rhododendron californicum, Myrica californica, Arctostaphylos nummularia and other species.

The plants of moist, shady spots in the redwood strip are Viola sarmentosa and Trientalis latifolia.

The boreal species are: Cornus canadensis, Arctostaphylos uva-ursi, Juncus supiniformis, Hypericum anagalloides, Drosera rotundifolia, Blechnum spicant, Ledum glandulosum, Sphagnum cymbifolium, S. mendocinum, S. subsecundum var. longifolium, Carex vallicola, C. salina var. mutica and C. livida.

The coast bluff species comprise Pinus contorta, P. muricata, Calamagrostis aleutica, Sisyrinchium californicum, Hosackia gracilis and Gentiana oregona.

The apparently endemic species are: Veratrum fimbriatum, Lilium maritimum, Campanula linnaeifolia, Carex phyllomanica, C. mendocinensis, C. gynodynamia, Agrostis Pringlei, Calamagrostis Bolanderi and C. crassiglumis.

## 2. Redwood Formations.

South of the Chetco River a continuous strip of redwood (*Sequoia sempervirens*) begins increasing in width in the river valleys and lowlands from 10 miles wide, in Del Norte County to 18 to 20 miles, ending in Mendocino County. Scattered forests of the species are growing in sheltered spots, as far south

as Salmon Creek Canyon in the Santa Lucia Mountains, 12 miles south of Punta Gorda.

The Redwood Slope Formation is the common type. It occurs on the steep sides of the Coast Range and is a mixture of Sequoia sempervirens, Pseudotsuga Douglasii, Quercus densiflora and Abies grandis with an occasional tree of Arbutus Menziesii, or the coast hemlock Tsuga Mertensiana. The redwood (Sequoia) is predominant in the mixture and the red fir (Pseudotsuga) ranks next with a dense undergrowth of Gaultheria Shallon, Acer macrophyllum, Rhododendron occidentalis, Berberis repens (= B. Aquifolium), Rubus nutkanus, etc. The herbaceous plants of this forest are Calypso borealis, Nephrodium (Polystichum munitum, Anemone nemorosa, Zygadenus paniculatus, Trillium ovatum, Adiantum pedatum, Viola sarmentosa, Cardamine paucisecta, Claytonia perfoliata, Erythronium giganteum, Oxalis oregona, Bromus laevipes, Melica bromoides, Hierochloë macrophylla, Trisetum canescens, etc.

Redwood Flat Formation. The redwood steadily gains on the other species and the forest becomes denser as the slopes become moderate, the altitude lower, the soil deeper and the water supply better. Associated with the redwood are Pseudotsuga, Quercus densiflora, Picea sitchensis, Chamaecyparis Lawsoniana, Thuja gigantea, Tsuga Mertensiana, Abies grandis, Taxus brevifolia, Torreya californica, Pinus contorta, Umbellularia californica, Arbutus Menziesii, Rhamnus Purshiana, Alnus oregona, Cupressus Goveniana [1].

Along the central portion of its range the redwood occupies the ground to the almost entire exclusion of all other trees. Its distinguishing features are the great size of the trees, their amazing vitality, producing a new growth from the charred stumps and the thickness with which they stand together. Nowhere is there such an amount of timber to the acre. The trees vary in height from 180 to 325 feet (55—100 m) and in diameter from nine to twenty (3—7 m). They stand so thickly, that there is not space for a team to pass between them. In Humboldt County some acres in flats along streams will yield as much as 500,000 feet B. M. [2].

### 3. Interior Upland Range Formations.

These formations include the extensive open ranges lying east of the redwood strip. These ranges are diversified by masses of *Pseudotsuga Douglasii*, oak woods, chemisal or mixed shrubby vegetation, open grassy slopes (so called prairies), tiny mountain meadows or wide enclosed valleys and with small patches of redwood in canyons, or cool slopes on their landward sides.

*Forest Formation.* The gulches and steep sides of the canyons, especially their eastern slopes are thickly covered with trees and underbrush. The prevalent trees are *Pseudotsuga Douglasii*, *Quercus californica* (6—7 feet in diameter), *Quercus Garryana*, *Q. densiflora* (sometimes 130 feet high, 7 feet diameter), *Arbutus Menziesii* and along the streams *Umbellularia californica*. Less abundant but by no means uncommon are *Pinus ponderosa*, *Castanopsis chrysophylla*, *Acer macrophyllum*, *Libocedrus decurrens*, *Cornus Nuttallii*, *Torreya cali-*

1) FISHER, RICHARD T.: A Study of the Redwoods, U. S. Bureau of Forestry. Bulletin 38, 1903.

2) The unit of board measure (B. M.) is the board foot, which is a board 1 inch thick and 1 foot square.

*fornica*, *Fraxinus oregona* with occasional trees of *Quercus lobata* and *Q. chrysolepis*.

The eastern and western sides of Red Mountain are peculiar in the presence of groves of *Cupressus Macnabiana*. The underbrush consists of *Corylus rostrata* var. *californica*, *Calycanthus occidentalis*, *Rhus diversiloba*, *Rhamnus californica*, *Rosa gymnocarpa*, *Gaultheria Shallon*, *Vaccinium ovatum*, *V. parvifolium*, *Rubus vitifolius* and in certain places *Ceanothus integerrimus*, *C. incanus* and *C. velutinus*. At Red Mountain grow *Lilium pardalinum*, *Aquilegia truncata*, *Epipactis gigantea* and a fern *Pellaea densa*.

*Chaparral Formation*. This formation consists of a thicket of low trees and shrubs. It is bushland or scrub. It coincides with dry stony ground and is composed of such shrubs as *Adenostoma fasciculatum*, *Ceanothus cuneatus*, *Quercus dumosa*, *Cercocarpus* sp., *Garrya Fremonti*, *Eriodictyon glutinosum* (= *E. californicum*).

The grasses usually found in such localities are *Melica californica*, *M. Harfordii*, *Elymus multisetus*, *E. planifolius*, *E. glaucus*, *Bromus carinatus* and occasionally *Festuca ovina* [1]).

The chaparral formation covers millions of acres of the high slopes on the north sides of the mountains of the Coast Range and rolling hills. Here, as near Ukiah [2]), the slopes facing south are grassy with scattering trees of *Quercus Douglasii* and *Aesculus californica* with many herbs in the spring.

The composition of the chaparral on the higher mountain slopes as about Lake Clear [3]) in the heart of the Coast Range is similar to that already described. Species of Adenostoma, Cercocarpus, Ceanothus and Arctostaphylos abound. There are besides clumps of Garrya Fremonti, scattered individuals of Ceanothus divergens, Quercus dumosa var. bullata and occasionally Rhamnus ilicifolia. Here too are Dicentra chrysantha, Linum californicum, L. spergulinum, Galium Andrewsii, Hypericum concinnum, Eriogonum dasyanthemum and Gnaphalium californicum. The bottle-stone, or obsidian supports Chorizanthe Clevelandi, Oxytheca hirtiflora, Scutellaria Bolanderi and Quercus Wislizeni. Opens in the chaparral are bright with Hypericum anagalloides, Silene californica, Eriogonum vimineum, Clarkia rhomboidea, Mentzelia micrantha, Eriophyllum caespitosum, Gomphocarpus cordifolius, Phacelia ramosissima, Emmenanthe penduliflora, Antirrhinum virga, Pentstemon azureus, Mimulus Bolanderi and Verbena prostrata.

### 4. Mountain Summit Formations.

Several mountains are sufficiently high to show a flora somewhat like that of the Sierra Nevada Mountains in appearance. Such are the San Hedrin Mountains, Mount Hull, Snow Mountain (8,048 feet = 2453 m), Mount St. John, Mayacamas Mountains and Mount St. Helena (4,343 feet = 1324 m).

*Forest Formation*. The trees of Snow Mountain [4]) and the elevation to which they reach are as follows: *Abies concolor* (4,000—6,000 feet = 1220—1830), *A. nobilis* (6,000 feet = 1525 m), *Pinus sabiniana* (3,800 feet), *Pinus*

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1) DAVY, JOSEPH BURTT: Stock Ranges of northwestern California. U. S. Bureau of Plant Industry Bulletin 12: 31.

2) PURDY, CARL: A Canon near Ukiah. Garden and Forest IX: 482, 493.

3) JEPSON, W. L.: The mountain Region of Lake Clear. Erythea I: 10.

4) BRANDEGEE, KATHERINE: Sierra Nevada Plants in the Coast Range. Zoe IV: 168.

*ponderosa* var. *Jeffreyi* (5,000 feet and upward), *Pinus Lambertiana* (at high elevations, becoming dwarfed), while the thickets are formed of *Ceanothus ledifolius*, *Quercus chrysolepis* reaching an elevation of 4,000 feet and dwarfing rapidly into its subalpine form var. *vacciniifolia*, while associated with the above are *Lophanthus urticifolius*, *Gilia aggregata*, *Spraguea umbellata*, *Eriogonum umbellatum*, *E. ovalifolium* and *E. Lobii*.

The arid summit of Mount St. Helena possesses a few species characteristic of the humid coast region, or of the high Sierras and other elevated mountain ranges, such as *Pseudotsuga Douglasii* and *Cornus Nuttallii*, while *Ceanothus velutinus* var. *laevigatus*, *C. prostratus* var. *divergens* and *C. foliosus*, all found on Mount St. Helena, are absent from the inner coast ranges and Diablo.

*Chaparral Formation.* The vegetation of the summit of Mount St. Helena is distinguished by the prevalence of shrubs of a limited number of species which completely mantle the sides of the mountain above 2,300 to 2,500 feet.

The shrubs are Arctostaphylos manzanita (with its root-parasite Boschniakia strobilacea) Garrya Fremonti, Pickeringia montana, Rhamnus californica, Ceanothus foliosus, Castanopsis chrysophylla, Quercus chrysolepsis, Q. Wislizeni with two other low shrubs: Dendromecon rigidum and Eriodictyon californicum. Pinus attenuata is scattered more or less all over the mountain with its parasite Areeuthobium occidentale. There is a conspicuous lack of herbaceous species above 3,000 feet and not a sign of an annual. Of herbaceous perennials there were found by JEPSON[1]) Hypericum concinnum, Pedicularis densiflora, Monardella odoratissima and Zygadenus Fremontii. The total number of plants collected above 3,000 feet and adapted to grow in the arid and gravel-covered areas of the high coast range ridges was twenty-one.

A subalpine Meadow Formation is found in the Trinity and inner Coast Range Mountains at an altitude of about 6,500 feet. There are bordered by Veratrum californicum, alpine species of Aster, Viola, Mimulus and Eriogonum spergulinum, while upon these meadows grow Ranunculus alismellus, Viola blanda, Gilia Harkensii, Mimulus primuloides, Polygonum bistortoides and Potentilla gracilis.

The crevices of rocks on the summit of Snow-Mountain are occupied by Galium multiflorum and Gilia pungens. The rocky areas are characterized by Raillardella Muirii, Eriogonum umbellatum, E. Lobbi, Polygonum Davisiae.

## 5. Mountain Valley Formations.

Nearly all the oblong or round valleys, common in the coast ranges north of San Francisco Bay were the beds of lakes. Clear Lake is a large body of water but Tull Lake is one that has been converted into a marsh covered by tall rushes while Ukiah Valley has been completely converted into dry ground. Each of the geologic formations has its flora.

Here exists a Marsh Meadow Formation: In the small marshes are Rumex persicarioides, Ludwigia (Isnardia) palustris, Nuphar advena, Brasenia peltata, Oenanthe californica, Alisma plantago. The floor of the valleys is virtually a meadow. Here grow bunch grasses, Lilium pardalinum, Calochortus lilacinus, C. venustus var. oculatus, Iris macrosiphon, Godetia viminea, Ranunculus macranthus, Sisyrinchium bellum. —

1) JEPSON, WILLIS L.: Vegetation of the Summit of Mt. St. Helena. Erythea VII: 105 Oct. 1899.

In the beds of streams grow Eriogonum virgatum, Mentzelia laevicaulis, Chrysopsis oregona, Senecio euryccephalus, Nicotiana attenuata, Verbascum virgatum, Mimulus pilosa, Trichostema laxum and Argemone munita = A. hispida.

Forest Formation. The benches along the edges of the valleys support a growth of trees among which may be mentioned Quercus Douglasii, Pseudotsuga Douglasii, Quercus lobata, Arbutus Menziesii, Fraxinus oregona, Quercus californica and Negundo californicum with thickets of Rosa californica and such lianes as Clematis ligusticifolia and Vitis californica.

## b) Santa Lucia Area.

This comprises the coast range country south of San Francisco Bay and as far south as Point Concepcion. It too is characterized by the presence of the redwood, but in isolated groves one in the Santa Cruz Mountains and a smaller one in the Santa Lucia Mountains.

### 1. Sea Coast Formations.

*Marine Algal Formation.* Out from the shore in the deeper water ot Monterey Bay [1]) occurs an association of seaweeds of gigantic size. Here are found *Macrocystis pyrifera*, *Iridaea laminarioides* and *Nereocystis Lütkeana* (*Macrocystis Association*). The tidal pools immediately along shore are characterized by *Cladophora scopaeformis*, *Ulva latissima*, *Halosaccion hydrophora* and species of *Gelidium*, *Prionitis* and *Nitophyllum* (*Cladophora Shelf*). The algal shelf uncovered with the retreat of the tides is characterized by the presence of *Fucus fastigiatus*, *F. Harveyanus* *F. evanescens*, *Codium tomentosum* and *Halidrys osmundacea* (at low tide mark).

*Coastal Bluff Formation.* In the absence of detailed information on the flora of this formation in general it may be said that three trees are characteristic of the coastal bluffs. Cupressus macrocarpa (see the next page Fig. 29) occupies a strip about two miles long and two hundred yards wide from Cypress Point to the shores of Carmel Bay, with a small grove on Point Lobos [2]). *Pinus insignis* (= *P. radiata*) is also restricted in its distribution being confined, to the country immediately adjacent to the Bay of Monterey where it forms a narrow forest a few miles long, back of the grove of *Cupressus macrocarpa*. *Pinus Torreyana* is found only on the border of the high bluff and on the sides of the ravines extending from it to the sea, north and south of Del Mar in San Diego County, where it stretches along the coast for a distance of nearly eight miles, but nowhere penetrates inland more than a mile and a half. A single grove of this tree also grows on the east end of Santa Rosa Island, off the California coast [3]).

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1) Howe, Marshall A.: A Month on the Shores of Monterey Bay, Erythea I: 63.

2) Sargent, C. S.: Manual of the Trees of North America, 78.

3) Pinus muricata; Garden and Forest X: 232; Sudworth, George B.: Forest Trees of the Pacific Slope. U. S. Forest Service 1908; Jepson, W. L.: Forest Trees of California 1909; Humphrey, H. B.: The plant Societies of Monterey Peninsula. The Plant World XII: 152—157; July 1909.

*Redwood Formation.* This formation south of San Francisco Bay is not in a continuous strip. Two large groves exist in the Santa Cruz and Santa Lucia Mountains, but the southern limit seems to be in San José Canyon several miles south of Carmel Bay and there is a grove of redwood about thirty five miles still farther south on the south fork of Sur Chiquito, a good sized trout-stream running through narrow canyons from its source to the ocean. All of the typically herbaceous, or undergrowth plants of the redwood forest are characteristically northern.

Fig. 29. *Cupressus macrocarpa* Hartweg. Monterey Cypress, confined to a narrow strip of coast land, several miles long near Monterey Bay, California. Coastal Bluff Formation. From "Country Life in America"; copyright 1902 by Doubleday, Page & Co.

## 2. Interior Upland Range Formations.

The information available concerning the vegetation of the southern coast ranges is limited in amount. In lieu of more material bearing on this subject, a description of the floras of Mount Diablo and Mount Hamilton will be given. The flora of these mountains and Mount St. Helena has been compared and the data have been given elsewhere in this book (see ante page 272).

Mount Diablo, 3,848 feet (1173 m) in elevation, is situated thirty miles inland. The vegetation is more rank than on Mount Hamilton forty miles farther south and protected from the ocean by the Santa Cruz Mountains[1]).

1) GREENE, E. L.: Vegetation of Mt. Diablo. Erythea I: 166. — Vegetation of the Summit of Mt. Hamilton, l. c. I: 77.

The chaparral formation consists of Adenostoma fasciculatum, Ceanothus cuneatus, associated with Quercus chrysolepis, Q. Wislizeni, Q. Douglasii and Pinus sabiniana. The vegetation of this mountain also comprises: Rhamnus ilicifolia (in well rounded clumps near the summit), Ribes subvestitum (at the summit), R. californicum (near the summit), Clematis lasiantha (climbing over shrubs near the summit), Aplopappus (Stenotus) linearifolius, a shrub of the south slope, while Streptanthus hispidus (endemic), Phacelia Breweri, Silene verecunda, Psoralea californica, Sanicula saxatilis, Helianthella castanea (endemic), Hosackia crassifolia, Campanula exigua, Arabis Breweri, Lathyrus vestitus and Collinsia tinctoria occupy rocky situations on the top of the mountain. The open spaces among the bushes are occupied by Eschscholtzia ambigua, Delphinium californicum, Arnica discoidea, Campanula exigua and Phacelia circinatiformis. Arabis Breweri, Erigeron foliosus grow on south slopes while Pentstemon corymbosus forms mats on the exposed rocks.

The vegetation of Mount Hamilton shows a marked xerophytic character as compared with that on Mount Diablo and Mount St. Helena. The absence of a true forest is noteworthy and the coast range oaks *Quercus dumosa*, *Q. Wislizeni*, *Q. agrifolia*, *Q. californica* (= *Q. Kelloggii*) occur more generally on the north slopes with *Quercus Douglasii* on the western flanks. *Pinus ponderosa* grows on the summits of high ridges, while *Pinus Sabiniana* occurs on the highest parts of the mountain. Species of *Ceanothus* are absent.

Other trees of the mountain are Cercocarpus parvifolius (= C. betulaefolius), Acer macrophyllum, Aesculus californica and Rhus diversiloba. The north slopes show the presence of Hosackia crassifolia, Eriogonum saxatile, Umbellularia californica (in gulches almost to the summit), Erigeron petrophilus (crevices of rock) and Pentstemon breviflorus.

South slopes are occupied by Eriogonum stellatum, E. trachygonum, Oenothera hirtella and Chlorogalum pomeridianum, while Holodiscus discolor is common along rocks and thickets on the highest ridges. Lewisia rediviva (see Fig. 22 page 338) also occurs on Mt. Diablo and in the Rocky Mountains of the northwest. Arenaria (Moehringia) macrophylla is plentiful on rocky slopes.

Abies venusta is a tree confined to the Santa Lucia Mountains and neighboring ranges and canyons. It occurs at least eighteen miles inland from the ocean on crags, rocky ridges, in canyons and along streams. In favorable localities where the chaparral does not occur it mingles with Pinus ponderosa, Pinus Coulteri to form considerable tracts into which Quercus chrysolepis, Q. californica (= Q. Kelloggii), Q. (Pasania) densiflora, Pinus attenuata, and Arbutus Menziesii extend. Elsewhere these mountains which rise to elevations of 4,500 to 5,000 feet are largely covered covered with chaparral [1]).

## B. San Joaquin District.

The central valley of California, situated between the Sierra Nevada Mountains on the east and the Coast ranges on the west, is drained by the Sacramento River running from the north toward the south to join the San Joaquin River which flows from the south toward the north. The stream formed by their confluence empties into San Francisco Bay. The topography and geologic history of this great valley situated almost at Sea level has been previously described (see ante p. 279). It remains to discuss the plant formations of this interesting plain.

1) DUDLEY, WILLIAM R.: A notable California Fir. Forestry and Irrigation, VIII May 1902: 193; PEIRCE, GEORGE J.: Botanical Aspects of Stanford University. The Plant World 12: 245—252 Nov. 1909.

*Grassy Plain Formation.* During the months of March, April and May the San Joaquin Valley was one smooth continuous bed of grasses, sedges and flowering plants for a distance of more than 400 miles. Each species usually dominated its own particular area, almost to the exclusion of others. Acre after acre, mile after mile were thus covered with masses of plants with flowers of bright blue, orange, white, yellow, pink or cream and the effect of the whole, especially during the month of April has been likened by one popular writer "to a huge patch-work quilt thrown on the ground". Flowering plants of the following genera were conspicuous: *Brodiaea*, *Gilia*, *Claytonia*, *Calandrinia*, *Nemophila*, *Castilleja*, *Lupinus*, *Trifolium*, besides numerous labiate and compositous genera [1]).

The only breaks in the continuity of these wild bee pastures were along the main streams and their tributaries, which entered at right angles from the mountains on either side and were fringed with trees. On the open flat country grew Platystemon californicus, Eschscholtzia californica and species of Bahia, Calandrinia, Madia, Madaria, Baeria, Burrielia, Chrysopsis, Corethrogyne, Amsinckia, Grindelia, Allocarya, growing in close association of various shades of yellow, blending finely with the purples of species of Clarkia, Orthocarpus and Oenothera. On account of the long period of drought, annuals which spring up quickly were and are still the rule in undisturbed places and the general appearance of uniformity was scarcely modified by the taller species of Phacelia, Pentstemon and associations of Salvia carduacea.

The growth of the months mentioned was stimulated by the winter rains which fall during December, January, February and early March. Following the spring months subsequent to May, the general brown and purple colors of the vegetation were the most marked characteristics of the plain. In October when the dry vegetation had crumbled to dust there was a second outburst of bloom, and Hemizonia virgata made its appearance in associations, miles in extent, a single plant bearing as many as 3,000 flowers, five eighths of an inch in diameter. This plant subsequently in November is associated with two or three species of Eriogonum and by tufts of Grindelia which continue until the spring flowers of January appear [2]).

The surface of the Tulare plains, except the alkaline bottoms, contained no shrubs, but a scant herbaceous growth of Eremocarpus, and herbs made up principally of annuals such as Croton californicus, C. setigerus and Asclepias erosa.

*River Bank Formation.* The river banks of the great valley are formed of silt and they separate the river channel from the marshes behind. The following trees and shrubs are characteristic river bank species:

| | |
|---|---|
| Salix nigra Marsh. | Platanus racemosa Nutt. |
| » sessilifolia Nutt. var. Hindsiana Anders. | Juglans californica Wats. |
| » lasiandra Benth. | Alnus rhombifolia Nutt. |
| » longifolia Muhl (= S. interior [Rowlee]. | Cephalanthus occidentalis L. |
| Populus Fremontii Wats. | Vitis californica Benth. |
| | Rosa californica C. & S. |

1) This account is written in the past tense, because the composition of the valley flora has been changed by the settlement of the country. The description is true, however for undisturbed sections of this Valley.

2) MUIR, JOHN: The Mountains of California, 1901: 339—359; JEPSON, WILLIS L.: The riparian Botany of the lower Sacramento. Erythea I (1893): 238. — A Flora of California. Illustrated. 1909—1910.

Rubus vitifolius C. & S.
Negundo californicum T. & G. (= Acer Negundo L. var. californicum Sargent).
Rhus diversiloba T. & G.
Quercus Wislizeni D.C.
Cornus pubescens Nutt. (= C. occidentalis T. & G.).

Oak Grove Formation. The bottomland nearer the foot hills is characterized by the presence of groves of Quercus agrifolia from three to eight feet in diameter which break the continuity of the prairie-like levels. Prof. SARGENT, in his Silva, writes of this oak: "The valleys and low hills of the California coast owe their greatest charm to this oak tree, which, dotting their covering of vernal green, or their brown summer surface with its low, broad heads of pale, contorted branches, and dense, dark foliage, gives them the appearance of incomparably beautiful parks".

*Tule Marsh Formation.* The course of the Sacramento River for a distance of 150 miles from its mouth is bounded by brackish marshes which stretch away from the river ten to fifteen miles on either side. These marshes are generally referred to as tule lands. Here *Scirpus lacustris* var. *occidentalis* chokes the marshland associated with *Scirpus tatora* forming thus almost pure associations covering extensive areas.

The islands separated from each other by a labyrinth of tortuous channels are all of the same character, consisting of pure and exceedingly fine vegetal mold arising from the decay of tule and without trace of sand or gravel. They are all either entirely or in great part below water.

While the vegetation of the grassy plains formation is brown in September and October, that of the river marshes is fresh and green. The color in these marshes in the autumn is dependent on the presence of Verbena hastata, Solidago occidentalis, Aster Douglasii, Stachys albens and Gnaphalium californicum. Annuals here are commonly four to six feet in height and plants eight to twelve inches high in dry soil here double their size, viz: Boisduvalia densiflora var. imbricata. Attention has already been called (see ante p. 280) to the fact that there is a strong resemblance between the flora of this formation and that of the low ground of the lower Mississippi River, but such plants as Lathyrus Jepsonii, Hibiscus californicus, Baccharis Douglasii are peculiar to California, while such herbs as Pluchea camphorata and Hypericum mutilum not only occur near the Mississippi, but in the salt marshes of the Atlantic coast as well.

## C. Sierra Nevadan District.

This is coincident with the Sierra Nevada Mountains of California extending from the Klamath Gap (50 miles wide) south, as far as Tehachapi Pass which may be taken as the dividing line between the Sierra Nevada Mountains proper and the mountains of southern California, including the San Bernardino Range. — The Siskiyou Mountains and the Mt. Shasta Range may be said to form one division of the Sierra Nevada District and the mountains south of the Pitt River Gap (60 miles in width) between Mount Shasta and Mount Lassen another.

### a) Shasta Area.

This area includes the mountainous country about Mount Shasta and the Siskiyou Mountains, which extend westward, until they blend with the Coast Mountains on the West. The effectiveness of the Klamath gap in acting

as a barrier between the Cascade and Sierra Nevada Mountains has been described (see ante p. 256.). It remains to discuss the plant formations of the Shasta Area.

1. Coniferous Forest Formations.

Mount Shasta rises from a forested region and the mountain itself is forest-covered up to an altitude of 7,500 to 8,000 feet. The trees of the lower slopes are those of the surrounding region, but those on the upper slopes are different [1]).

*Pinus ponderosa Belt.* This formation is an open forest belt extending up to an altitude on the south and west sides to about 5,500 feet. *Pinus ponderosa* is the most characteristic tree of this formation and the lower slopes. The only gap in the continuity of this forest is a strip about 8 miles (12,8 km) in length on the cold northeast slopes, where *Pinus Murrayana* grows. On the south and west, the open pine forest of the basal slopes is interrupted by extensive parks of chaparral consisting of *Arctostaphylos patula* and *Ceanothus velutinus*. Northwest of Shasta the forest of Pinus ponderosa is interrupted by the open plain of the Shasta Valley: on the south it is practically continuous to the base of Lassen Butte and thence along the flanks of the Sierra for 350 miles (472 km); on the southwest, according to Merriam, it follows the canyon of the Sacramento River to a little below Delta, where, in the bottom of the canyon and warmer slopes it mixes with *Pinus sabiniana*. On the cooler and higher canyon slopes and adjacent foot hills *Pinus ponderosa* continues to the border of the Sacramento Valley. West of Shasta this formation covers all but the highest elevations of the Scott Mountains and reach up a considerable distance over the east arm of the Salmon Mountains where *Pinus ponderosa* is mixed with *Pseudotsuga Douglasii*, *Pinus Lambertiana* and *Libocedrus decurrens*. Still farther west the forest of *Pinus ponderosa* occurs in greater or less extent in the valleys of Russian Creek, north and south forks of Salmon, Trinity and Klamath rivers and at appropriate altitudes on the west arm of Salmon and Trinity Mountains [2]).

The forest of Pinus ponderosa is nowhere pure over any large area, but is sprinkled with Pinus Lambertiana, Liboeedrus decurrens, Pseudotsuga Douglasii, Abies concolor var. Lowiana, Pinus attenuata (a narrow interrupted tongue of which pushes up Panther Creek) Quercus californica (= Q. Kelloggii), Acer macrophyllum, A. glabrum, A. circinatum, Alnus tenuifolia. The chaparral of this belt consists of Ceanothus cordulatus, C. integerrimus, C. (Cerastes) prostratus, C. velutinus, and Cercocarpus ledifolius.

*Abies shastensis Belt.* This belt [3]) is not connected with similar forests elsewhere, because it occupies Mount Shasta above the forest of *Pinus ponderosa*. It forms a belt averaging two or three miles in breadth and 2,000

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1) MERRIAM, C. HART: Results of a biological Survey of Mount Shasta California. North American Fauna. No. 16, 1899: 30.

2) SHINN, CHARLES H.: Among the Siskiyou Forests. Garden and Forest II: 598, Dec. 11, 1889.

3 COVILLE, C. V.: The Shasta Fir. Garden and Forest X: 516.

feet in vertical range completely encircling the mountain, beginning at an altitude of 5,000—5,500 feet and pushing up to 7,500 or 7,800 feet. It is the distinctive forest of Shasta, a forest of tall stately trees, dark somber and free from underbrush, though here and there *Arctostaphylos nevadensis* forms patches which breaks the monotony of the dark brown surface. *Evernia vulpina*, a yellow lichen, drapes the lower branches of this tree, while the pendant masses of *Alectoria Fremonti* occur in the denser parts of the forest. As a rule, the Shasta fir *Abies shastensis* (= *A. magnifica* var. *shastensis*) stops where *Pinus albicaulis* begin, but the fir at its upper limit is of full size except on the steep and relatively warm southwestern slopes, where dwarf specimens occur. The highest point at which this tree grows is at an altitude of 8,900 feet (2710 m). This type of forest is mainly pure, but in places, particularly on the east and northeast sides of Mount Shasta, *Pinus monticola* is scattered through it and in one place *Pinus Murrayana* replaces *Abies shastensis*.

The herbaceous associates[1] of Shasta fir are: Aconitum columbianum, Allium validum, Arnica longifolia, Campanula Wilkinsoniana, Chimaphila Menziesii, C. umbellata, Corallorhiza Bigelovii, Delphinium Sonnei, Epilobium brevistylum, E. oregonense, E. spicatum (= angustifolium), Gentiana simplex, Habenaria leucostachys, H. unalaschensis, Heracleum lanatum, Lilium parvum, Lupinus Elmeri, Madia Bolanderi, Pentstemon deustus, P. gracilentus, Pirola pallida, P. picta, P. secunda, Senecio trigonophyllus, Tofieldia occidentalis and Viola blanda. As there is practically no undergrowth, shrubs form an insignificant part of the forest of this formation. The following, however, are present: Alnus sinuata, Arctostaphylos nevadensis, Ribes amictum, R. cereum, Sorbus sambucifolia and Vaccinium occidentale.

*Pinus albicaulis Belt.* This belt extends from the belt of *Abies shastensis* to the fields of perpetual snow and timber line. It is an open belt of straggling, irregular trees whose whitened, twisted trunks show every evidence of their storm-beaten environment. *Pinus albicaulis* in the lower part of the belt often attains a height of 30 or 40 feet and a diameter of two feet. In the higher elevations it is restricted to the ridges, leaving the intervening basins and gulches bare. Finally the trunks become completely prostrate and the branches hug the ground extending upward on the hottest ridges to an extreme limit of 9,800 feet (2987 m). In places this tree is mixed with and occasionally is replaced by mountain hemlock, *Tsuga Pattoniana* which never reaches as high, because more moisture loving, and it, therefore, reaches its altitudinal limit one thousand feet lower than *Pinus albicaulis*. The hemlock forest, where it is pure, is dark and somber and the lower limbs of the trees are draped with *Alectoria Fremontii* and *Evernia vulpina*.

In moist spots particularly along the borders of rivulets Bryanthus empetriformis forms beds with Eriogynia pectinata spreading a faint veil of green over the dark soil. In the drier parts of the forest hardly a plant is seen except now and then a solitary specimen of Chimaphila Menziesii or Pirola picta. Juniperus nana occurs in this belt as do such woody plants as Ribes cereum and Vaccinium caespitosum. Some of the herbaceous plants accredited to this belt of Pinus albicaulis are: Castilleja affinis, Crepis intermedia, Cycladenia humilis, Epilobium Pringleanum,

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1) MERRIAM loc. cit. page 63.

Lupinus albifrons, Monardella odoratissima, Claytonia triphylla, Orthocarpus pilosus, Pentstemon glaber var. utahensis, P. Newberryi, Potentilla flabellifolia, P. pseudorupestris, Scutellaria nana, Spraguea umbellata, Stellaria (Alsine) crispa.

### 2. Alpine Formation.

This belt occupies the pumice[1]) and lava between timberline and the upper limit of plant growth. On the warmer southwestern slopes its lower limit may be found at 9,500 to 9,800 feet. The great majority of alpine species stop at or below an altitude of 11,000 feet, but on the relatively warm southwestern slopes *Hulsea nana* was found at 11,300 feet (3445 m), and *Draba Breweri* and *Polemonium pulchellum*, as high as 13,000 feet (3962 m), the extreme limit of plant growth on Mount Shasta.

The species known to occur in the alpine belt of Mount Shasta are:

Achillea borealis.
Agoseris (Troximon) monticola.
Antennaria media.
Arabis platysperma.
Aster shastensis.
» alpiginum.
Cardamine bellidifolia var. pachyphylla.
Carex Breweri.
Chaenactis nevadensis.
Chrysothamnus Bloomeri.
Cymopterus terebinthinus.
Dicentra uniflora.
Draba Breweri.
Elymus cinereus.
Erigeron armerifolius.
Erigeron compositus var. trifidus.
Eriogonum polypodum.
» pyrolaefolium.
Eriogynia pectinata.
Erysimum (Cheiranthus) perennis.
Hieracium albiflorum.
» gracile.
» horridum.
Hulsea Larseni.
» nana.
Juncus Parryi.
Ligusticum Grayi.
Lupinus Lyalli.
» ornatus.
Oxyria digyna.
Pentstemon Menziesii.
Phacelia frigida.
Polemonium pulchellum.
Polygonum Newberryi.
» shastense.
Pulsatilla occidentalis.
Sagina saginoides (= S. Linnaei).
Saxifraga Tolmiei.
Senecio canus.
Sibbaldia procumbens.
Silene Grayi.
« Suksdorfi.
Spraguea umbellata.
Streptanthus orbiculatus.
Veronica Cusickii.
Viola purpurea.

## b) Sierra Area.

The Sierra Nevada Mountains proper begin in the neighborhood of Lassen's Peak and trend approximately south to Tehachapi Bay, where they blend with the mountains of southern California, the San Bernardino and Coast ranges. The flora of this area has long attracted botanists, and it is fairly well known.

### 1. Foothill and Mountain Formations.

*Forest Formations.* Beginning at the lowest elevations on the west slopes of the Sierras in proximity to the San Joaquin Valley, the following forest belts can be distinguished: The Foothill belt, may be subdivided into the open foothills (500—2,500 feet) and the chaparral (2,500—4,500 feet). The trees of the foothill forests are *Quercus Wislizeni* (500—4,000 feet), *Ceanothus cuneatus* (1,000—3,500 feet), *Aesculus californica* (500—3,000 feet).

1) Pumice is spongy volcanic scoria, or lava, usually in loose pieces.

In these foothills appears Quercus Douglasii (500—2,500 feet) associated with Rhamnus californica (ranging to 6,000 feet), Rhus diversiloba (to 3,500 feet), Senecio Douglasii (to 2,500 feet), Lupinus Chamissonis (to 1,700 feet), Ceanothus californicus (= C. integerrimus), Ribes velutinum (at about 1,600 feet), Calycanthus occidentalis (1,700—3,500 feet), Eriodictyon glutinosum (1,700—4,500 feet). The digger or nut pine Pinus sabiniana is the first coniferous tree met in ascending the range from the west and it is scattered singly or in groups of five, six trees. Its extreme upper limit is 4,000 feet. Its range follows closely the limit of the arid belt, it does not extend into the valley plain, but is generally restricted to an elevation between 500 and 2,500 feet. Pinus attenuata (= P. tuberculata) is found at an elevation of from 1,500 to 3,000 feet growing in close groves.

Near the lower border of the chaparral or brush appear *Fremontia californica* (2,500—4,000 feet), *Fraxinus dipetala* (2,500—3,500 feet), *Ceanothus divaricatus* (2,700 to 4,000 feet), *Bigelovia arborescens* (2,500—4,000 feet), *Cercocarpus parvifolius* (3,800—4,000 feet), *Quercus Breweri* (3,500—5,500 feet, preferring northward or northwestward slopes), *Quercus dumosa* (4,000—4,300 feet, inclined to grow in thickets), *Dendromecon rigidum* (3,800 feet), and *Prunus subcordata* (4,300—4,500 feet [1]).

The Pinus ponderosa Formation constitutes a belt of forest ranging from 2,500 feet to 6,500 feet in the northern Sierras.

The trees of this belt are Pinus ponderosa (6—8 feet in diameter, 220 feet in height), P. ponderosa var. Jeffreyi (attaining its best development in the north), Pinus Lambertiana (6—12 feet in diameter, 245 feet high), Pseudotsuga Douglasii, Abies concolor, Abies magnifica, Libocedrus decurrens (ascending to 5,000 feet on the warmer hillsides), Taxus brevifolia (along main range of Sierra in shady dells), Torreya californica (in gulches), Populus trichocarpa, Alnus rhombifolia, Castanopsis chrysophylla, Quercus chrysolepis, Q. californica (= Q. Kelloggii), Q. dumosa, Q. densiflora, Cercocarpus parvifolius var. breviflorus, Prunus demissa, P. subcordata, Acer macrophyllum, Rhamnus Purshiana, Cornus Nuttallii and Arbutus Menziesii.

The most remarkable tree of this belt is *Sequoia gigantea* (= *S. Wellingtonia*), the California big tree (see plate III at page 200, Calaveras Grove). It extends in widely interrupted groves from the middle fork of the American River to the head of Deer Creek, a distance of about 260 miles, the approximate elevation being from 5,000—8,000 feet [2]). From the American River Grove to the forest on Kings River the species occurs in small isolated groups, but from Kings River southward *Sequoia gigantea* extends across the broad rugged basins of the Kaweah and Tule rivers in noble forests, a distance of nearly seventy miles, the continuity of this part of the belt being broken only by deep canyons (see pages 199—200). As we advance southward, these forest giants become more and more irrepressibly exuberant. According to my observations in the Calaveras and Tuolumne groves, the growth is not pure, but nevertheless, there are trees which measure over 300 feet in height and a stem

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1) Dudley, William R.: Zonal Distribution of Trees and Shrubs in the southern Sierra. Sierra Club Bulletin No. 24, June 1901: 298—312; Hansen, George: Ceanothus in Landscape of the Sierra Nevada. Garden and Forest X, 1897: 102—103.

2) See Muir, J., in the Bibliography p. 80; Sudworth, G. B., ante p. 81 (U. S. Geol. Surv. 505—561); Leiberg, John B., in California Professional Paper No. 8, 1902: Series H. Forestry 5; Dudley, W. R., in U. S. Divis. of Forestry, Bull. 28, 1900.

diameter of from 20 to 30 feet. In the Kings River forest a tree was measured by JOHN MUIR with a diameter inside the bark of 35 feet 8 inches, four feet from the ground, and perhaps 5,000 years old, or less [1]. In the northern Sierra Nevada Mountains the trees of this type of forest mix along the upper limits of their range with *Abies shastensis* (= *A. magnifica* var. *shastensis*).

In this forest, according to my observations, occur Chamaebatia foliolosa, Lilium parvum, L. Washingtonianum (with pure white flowers), Dicentra formosa, Rhododendron (Azalea) occidentalis, Sarcodes sanguinea and under trees of Sequoia in the Calaveras Grove, I noticed Pterospora andromedea and Pleuricospora fimbriolata. Beneath Pinus Lambertiana in the Yosemite grows Ceanothus integerrimus, associated with C. prostratus, which together form mats on warm ridges. Elsewhere occurs Ceanothus cordulatus in extensive thickets, while Rhododendron occidentale inhabits the banks of cool streams, with Rubus nutkanus. — In the southern Sierras, according so ALICE EASTWOOD [2] near Kings River Canyon under the Sequoias along streams is found Athyrium (Asplenium) cyclosorum var. strictum.

In the upper pine forests, according to ENGLER [3] the following species are endemic: Arabis platysperma, Arenaria compacta, Arctostaphylos nevadensis, Artemisia Rothrockii, Aster Andersonii and Bigelovia (Chrysothamnus) Bolanderi.

River Bank and Rocky Slope Formation. The Yosemite Park occupies a natural valley surrounded by precipitous mountain walls. The Merced River that flows through the valley and the rivers of similar valleys in the Sierra Nevada Mountains are fringed by Salix lasiandra var. caudata, S. fluviatilis, Populus trichocarpa, Alnus tenuifolia, Taxus brevifolia (in the canyons) and Prunus demissa, while Selinum capitellatum, Mimulus luteus, Pentstemon Bridgesii occur on the banks of streams throughout the Yosemite Valley. Saxifraga peltata occurs along the borders of Cascade Creek and other streams in the Sierras. — At the altitude of the Yosemite Valley, the plants which characterize the steep canyon walls, rocky places or talus slopes are: Cryptogramma acrostichoides, Cheilanthes gracillima, Pentstemon breviflorus, Sedum spathulifolium, S. obtusatum, S. Rhodiola (= Rh. rosea), Gayophytum ramosissimum, Hieracium Breweri (rocky clifts), Draperia systyla, Pentstemon azureus, P. lactus, Antennaria argentea and A. luzuloides.

*Wet Meadow Formation.* The wet meadows of the Kings River Canyon and the Yosemite Valley are characterized by the presence of many perennials.

Allium validum, Lilium pardalinum, Veratrum californicum, Iris missouriensis, Habenaria leucostachys, Epipactis gigantea may be mentioned together with Ranunculus alismaefolius, R. orthorhynchus, R. occidentalis, Aquilegia truncata, Aconitum columbianum (and var. Eisenii), Caltha biflora, Sidalcea reptans, Hypericum Scouleri, Viola blanda, Geranium Richardsonii, Saxifraga integrifolia, Rosa gratissima, Trifolium microcephalum, Gayophytum diffusum and pumilum, Pedicularis groenlandica and attolens, Mimulus Bigelovii, primuloides and moschatus, Stachys albens, Heleniastrum rivulare, Senecio aureus, Chaenactis glabriuscula, Nuphar polysepalum (in open pools), Claytonia Chamissonis, C. parvifolia and exigua, Hosackia crassifolia, Potentilla gracilis and Dodecatheon Meadia. Alnus viridis and Corylus rostrata fringe the edges of such meadows. The pitcher plant, Darlingtonia californica, grows in marshy places from Mount Shasta to the coast associated with Habenaria leucostachys.

1) Die "Mark Twain" genannte Sequoia, von welcher eine mächtige Stammscheibe das Museum of Natural History, New York, ziert, hatte bei einem Umfang von 62 engl. Fuß (8 Fuß über dem Boden gemessen) noch nicht ein Alter von 2000 Jahren. — Siehe Supplement to American Museum Journal II Nr. 8, Nov. 1902, mit Karte der Verbreitung von Sequoia in Californien.

2) EASTWOOD, ALICE: A Flora of the south Fork of Kings River. Publications of Sierra Club, No. 27, June 1902.

3) ENGLER, A.: Die pflanzengeographische Gliederung Nordamerikas, 64.

## 2. Formations of the higher Sierra.

*Subalpine Forest Belt.* This formation, or forest belt, seems at first but a thinner upper fringe to the magnificent forest composed of *Pinus ponderosa*, *P. Lambertiana* and *Sequoia gigantea*. There is, however, no species of tree common to the two belts, or extending much from one into the other. The composition of this higher forest belt varies.

In the northern Sierra Nevada Mountains, it occurs above 5,800 feet on the western slopes and above 7,300 feet on the eastern and trans-sierran slopes. There the Shasta fir Abies shastensis is the prevailing tree forming fully 83 per cent of the forest associated with Pinus Murrayana (12 per cent, Pinus monticola 3 per cent), mountain hemlock, Tsuga Pattoniana (= T. Mertensiana, 2 per cent, Pinus albicaulis with Populus trichocarpa, P. tremuloides Cercocarpus parvifolius, Castanopsis chrysophylla, Arctostaphylos pungens, while Ceanothus cordulatus constitutes the underbrush above 7,000 feet.

This forest in the neigborhood of Lake Tahoe and Yosemite Valley consists essentially of three conifers: Pinus Murrayana, Abies magnifica, and Pinus ponderosa var. Jeffreyi. The other coniferous and broad leaved trees form no considerable part of the forests. Associated with the species named above are Pinus monticola, Pinus albicaulis, mountain hemlock Tsuga Pattoniana, Abies concolor, Juniperus occidentalis, Populus tremuloides, Alnus tenuifolia, Prunus emarginata and Acer glabrum.

On Mount Rose at the western edge of the Nevada Desert above Reno at about 7000 feet (2130 m) on this Sierra peak there are forests of Pseudotsuga Douglasii, Pinus ponderosa, Libocedrus decurrens with such shrubs as Arctostaphylos nevadensis, A. pungens, Castanopsis chrysophylla, Ceanothus prostratus, C. velutinus, Cercocarpus ledifolius and Ribes cereum, together with such herbs as Arabis pedicellata, Erysimum asperum, Gilia aggregata, Monardella odoratissima and Pentstemon deustus. At the upper limits of Pinus ponderosa 9000 feet (2743 m) on Mount Rose is a facies of Pinus Murrayana and, scattered on protected north-facing slopes, Tsuga Pattoniana and in protected canyons Pinus monticola.

Pinus Murrayana forms the bulk of the subalpine forests near Yosemite Valley. As a tree, it is widely distributed between 6,000 and 9,300 feet, while the area of its greatest abundance lies between 6,000 and 8,500 feet. On higher ground, it is associated with Pinus ponderosa var. Jeffreyi, Abies magnifica, Pinus monticola and Tsuga Pattoniana here forming 50 per cent of the stand. This tree shows a remarkable edaphic adaptation. It thrives best in meadow bottoms, but spreads persistently over low rock ridges and stretches of high granite plateaus, establishing itself everywhere in crevices and pockets. — The range of Abies magnifica is between 6,000 and 8,500 feet and the prevailing growth lies between 6,500 and 7,500 feet where forests of pure growth are frequent on the soil-covered lava rock benches on the eastern, southern and western slopes of the larger mountain peaks and ranges. Pinus monticola is rather rare but widely distributed between 6,500 and 9,400 feet. It appears as scattered individuals associated with Abies magnifica, Tsuga Pattoniana or less frequently with Pinus Murrayana. Tsuga Pattoniana (= T. Mertensiana) is a strictly subalpine tree, confined chiefly to northern slopes at elevations between 6,900 and 9,400 feet. It is generally distributed within these limits and associated with Pinus Murrayana only or with Pinus monticola, P. Murrayana and Abies magnifica; while in its highest range it occurs in small groups by itself or interspersed with Pinus albicaulis.

Pinus albicaulis grows among broken bare rocks and in beds of disintegrated granite at elevations between 8,000 and 9,500 feet, forming small patches of stunted and storm-beaten trees with which except at the upper levels, are interspersed groups and single trees of mountain hemlock, Pinus monticola and Pinus Murrayana. At the upper limits of its distribution Pinus albicaulis is the only tree and fixes timber-line. As a tree, it grows on eastern, southern and

western slopes only[1]. The shrubs of this belt are Ceanothus prostratus, Quercus chrysolepis var. vaccinifolia, and Castanopsis chrysophylla var. minor abundant at the higher elevations. — Juniperus occidentalis is a tree of high altitudes and exposed situations. It is nowhere abundant, but is frequent as a scattered tree between 7,000 and 8,500 feet elevation on bare granite rock slopes and low summits. On Mount Rose in western Nevada (10,800 feet) from 9,000 to 10,000 feet Pinus albicaulis is associated according to Kennedy (Muhlenbergia III: 30) with Cystopteris fragilis, Agrostis Rossii, Phleum alpinum, Poa Olneya, Poa reflexa, Stipa occidentalis, Salix glaucops, Eriogonum Lobbii, Sibbaldia procumbens, Lupinus cytisoides, L. leucophyllus, Trifolium monanthum (abundant in meadows), Rhodiola integrifolia, Ribes lentum, Antennaria dioica, Senecio triangularis and Solidago multiradiata.

To conclude our account of the forest flora of Sierra Nevada Mountains we find on the eastern side a desert region[2]) whose lower altitudes lie in a belt marked below by the presence of *Larrea Mexicana* (= *Covillea tridentata*) and above by a narrow treeless belt characterized by several shrubs and in many parts by an abundant growth of *Yucca arborescens;* and next a belt covered by a scant forest of *Pinus monophylla* (from the desert margin to 8,000 feet) *Juniperus californica* var. *utahensis* and *Pinus flexilis* seldom found lower than 9,000 feet, but from this elevation it pushes upward over the roughest ledges to the extreme limit of tree growth. The foxtail pine, *Pinus aristata*, is also another denizen of the eastern slopes of the sierras restricted to the southern portion of the range about the head waters of Kings and Kern rivers where it forms extensive forests above 9,000 feet. It ascends to 11,000 feet without seeming to suffer from the climate. *Pinus monophylla* is, however, commonest tree and covers many mountains from base to summit associated with a sparse growth of the juniper on the lower slopes, thus breaking the continuity of the nut pine forest[3]).

*Alpine Lakes and Meadows.* Thousands of lakelets exist in the sierras. They occupy the sheltered hollows of glacial valley basins, or are streams dammed by ancient moraines, or they exist in chains on mountain streams, as in Lake Hollow in Tuolumne Canyon, where ten such lakes lie together. The outer circumarea is characterized by *Spiranthes Romanzoffiana*, *Sagittaria variabilis*, *Damasonium californicum*, *Caltha leptosepala*, *Veratrum californicum*, and species of *Isoëtes*, *Narthecium*, *Habenaria*, and *Hastingsia.* The second circumarea, the lake-bog circumarea, is marked by the presence of *Ranunculus Andersonii*, *R. oxynotus*, *R. alismaefolius*, *Dodecatheon alpinum*, *D. Jeffreyi* and *Kalmia glauca* var. *microphylla.*

The alpine meadows are smooth, silky lawns representing the basins of lakes which have been converted first into bogs and then into meadows with

1) LEIBERG, JOHN B.: Forest Conditions in the northern Sierra Nevada, and MUIR, JOHN: The Mountains of California 1901: 138—225, see ante p. 267.

2) See Great Basin Region.

3) JEPSON, WILLIS L.: Mount Whitney, etc. Sierra Club Bulletin IV, No. 3, 1903: 207—215; MUIR, JOHN: loc. cit. 215—222; COVILLE, F. V.: Bot. Death Valley Exp. p. 26, see ante Bibliography p. 75.

a close and fine sod. They abound throughout the alpine and subalpine belts of these mountains.

The vegetation consists of species of Calamagrostis, Gentiana, Solidago, Ivesia, Orthocarpus, Pentstemon, Trifolium and masses of the genera Hypnum, Dicranum, Polytrichum, while mats of Salix glauca var. villosa, Bryanthus Breweri and Vaccinium caespitosum occur in such meadows[1].

The Hanging Meadow Formation is found aslant upon moraine covered hillsides, trending in the direction of greatest desclivity in the alpine and subalpine belts. The following genera of plants are represented: Lilium, Delphinium, Lupinus, Senecio, Allium, Castilleja, Mimulus, Pentstemon, Aquilegia, Silene, Wyethia, Erigeron, Phlox, Zauschneria, etc. Compare the alpine flora of this belt according to ENGLER[2].

The alpine summit of Mount Rose above Truckee Valley in western Nevada is subject to winds of great velocity which in winter blow the snow out of the crevices of the rocks, so that many of the alpine species are exposed to extreme wintry conditions. The alpine belt begins with the prostrate form of Pinus albicaulis (10,000 feet) and here occur the arctic willow, Salix petrophila, Arabis depauperata, Arenaria Nuttallii, Castilleja inconspicua, Cerastium Behringianum, Draba densifolia, Eriogonum rhodanthum, Festuca Kingii, Gilia montana, Oxyria digyna, Pentstemon Davidsonii, Phlox condensata, Poa longipedunculata, Polemonium montrosense, Raillardella nevadensis, Ribes Churchii, Senecio occidentalis and Trisetum subspicatum var. molle.

## D. San Bernardino District.

This phytogeographic district comprises that part of the California west of the Colorado and Mohave deserts and includes the San Bernardino and other ranges of mountains as also the coast plain south of a line which follows the Cuyama, or Santa Maria River and the Tehachapi range of mountains, or approximately that part of California, including the detached islands, south of the 35th degree of north latitude. Its southern boundary is marked by the Sonoran Desert Region. A sketch of the origin of the flora and its affinities has been given and a detailed statement with reference to the different floral elements is not necessary at this point (see ante p. 274).

It has been thought expedient to deal with the island flora as distinct from that of the mainland.

### a) Insular Territories.

The islands concerned in this sketch are San Miguel, Santa Rosa, Santa Cruz, Ana Capa, forming a northern group, and San Nicholas, Santa Barbara, Santa Catalina and San Clemente, forming a southern group. These islands are remarkable continental islands presenting in their flora many points of divergence from that of the adjacent mainland, for example, the absence of such prevailing genera as *Ribes*, *Lupinus*, *Astragalus*, *Potentilla*, *Horkelia* and in the presence of such genera as *Lyonothamnus*, *Crossosoma* and *Lavatera* absolutely peculiar to them. Such locally distributed mainland trees, as *Pinus Torreyana*, *Malacothrix incana* and *Leptosyne gigantea* are on the islands luxuriant and abundant.

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1) SHINN, CHARLES H.: The wild Gardens of the Sierra, IX (1896): 343.

2) ENGLER, A.: Die pflanzengeographische Gliederung Nordamerikas, 65.

San Miguel is the most seaward of the northern group and is of the nature of a table-land its shores rising for the most part abruptly to the height of from 200 to 300 feet. The two greatest elevations are respectively 861 and 850 feet. Unprotected by Point Concepcion its condition is one of perpetually wind-swept and wave-beaten exposure [1]).

The only arborescent species are Heteromeles arbutifolia and Rhus integrifolia (now extinct), Lavatera assurgentiflora existing in an open grassy valley. The bulk of the present vegetation consists of insular species among which the following are endemic: Eschscholtzia maritima, Astragalus miguelensis, Oenothera nitida, Galium miguelense, Phacelia scabrella and Corethrogyne filaginifolia var. robusta, Eriogonum rubescens, Malacothrix incana and Abronia villosa.

Several continental species grow on this island but not on the others, viz: Aplopappus ericoides, Troximon grandiflorum, Sidalcea malvaeflora, Gilia micrantha, Plantago hirtella and Scirpus riparius. — The grasses which carpet the island are of the perennial kind and the turf is constituted by two or three species of Elymus and Agropyron sparingly found on the mainland. The presence of these perennial grasses which form a rich pasturage for cattle is attributable to the ocean fogs. Mesembryanthemum crystallinum covers hundreds of acres of higher and somewhat argillaceous land.

Santa Rosa Island, not so mountainous in its topography as Santa Cruz, possess a flora smaller in number of species. The shrubby vegetation and trees confined to the sheltered hillsides and canyons are: *Pinus radiata* (= *P. insignis* var. *binata*), *Quercus dumosa*, *Q. lobata*, *Q. tomentella*, *Q. agrifolia*, *Populus trichocarpa*, *Salix laevigata*, *Lyonothamnus asplenifolius*, *Heteromeles arbutifolia* and *Prunus ilicifolia*. *Pinus Torreyana* is represented by about one hundred trees growing on the bluffs of the eastern shore [2]).

The trees of Santa Cruz are *Acer macrophyllum*, *Prunus ilicifolia*, *Cercocarpus parvifolius*, *Heteromeles arbutifolia*, *Salix laevigata*, *S. lasiolepis*, *S. longifolia*, *Populus trichocarpa*, *P. Fremonti* var. *Wislizeni*, *Quercus agrifolia*, *Q. chrysolepis*, *Q. Wislizeni*, *Q. oblongifolia*, *Q. lobata*, *Q. dumosa*, *Q. tomentella*, *Pinus radiata*, while as shrubs are found *Dendromecon rigidum*, species of *Rhus*, *Cercocarpus*, *Rosa*, *Lyonothamnus*, *Ribes*, *Sambucus*, *Symphoricarpos* and *Arctostaphylos*.

Santa Catalina is formed by two mountain masses, which reach an elevation between 2,000 and 3,000 feet. Few trees grow on this island, but there are many large shrubs and the flora in general resembles that of Santa Cruz Island. The abundance of *Crossosoma californica* and *Rhus laurina* seems to be an important difference (Litt. see BRANDEGEE).

Omitting a consideration of the flora of San Clemente Islands (see ante p. 277), it may be said in general that by far the larger part of the island flora is composed of maritime and coast range plants that delight in ocean breezes, spray and fogs. The great extent of the coast line of the islands affords a large habitat for a maritime flora and many mainland shrubs and bushes do not develop their lower limbs and branches on the islands and,

1) GREENE, E. L.: see Bibliography p. 80; see ante pages 275—278.

2) BRANDEGEE, T. S.: Santa Rosa Isl. Bibl. p. 79.

therefore, become tree-like, as for example, *Prunus ilicifolius*, *Cercocarpus*, *Rhus*, *Rhamnus* and *Ceanothus*.

The flora of Guadalupe Island[1]) 100 miles off the coast of Lower Californica, and rising from an oceanic abyss, is essentially Californian, as distinguished from the Mexican flora to which belongs the vegetation of the intervening peninsula of Lower California and the nearby islands. Trees are numerous over much of the island represented by *Pinus radiata* (= *P. insignis*) which exists in groves on the high narrow ridge at the northeast extremity of the island, *Cupressus guadalupensis*, *Juniperus californica* var. *osteosperma* in irregular groups on the middle of the island, *Quercus tomentella* and a palm: *Erythaea edulis*.

On ascending from the narrow beach to the plateau or table land 3.000 feet high the following plants occur: Senecio Palmeri, Sphaeralcea sulphurea, Hosaekia ornithopus, Convolvulus macrostegius, all endemic species associated with Brodiaea capitata. The following list so far as known comprises the plants peculiar to the island, as given by VASEY and ROSE:

1. Eschscholtzia Palmeri Rose.
2. Lavatera occidentalis Wats.
3. Sphaeralcea sulphurea Wats.
4. » Palmeri Rose.
5. Lupinus niveus Wats.
6. » guadalupensis Greene.
7. Trifolium Palmeri Wats.
8. Hosackia ornithopus Greene.
9. Oenanthe guadalupensis Wats.
10. Megarrhiza guadalupensis Wats.
11. Galium angulosum A. Gray.
12. Diplostephium canum A. Gray.
13. Hemizonia (Hartmannia) frutescens A. Gray.
14. » Greeneana Rose.
15. » Palmeri Rose[2]).
16. Perityle incana Gray.
17. Baeria Palmeri A. Gray.
18. Krynitzkia foliosa Greene.
19. Harpagonella Palmeri A. Gray.
20. Phacelia phyllomanica A. Gray.
21. » floribunda Greene.
22. Convolvulus occidentalis A. Gray.
23. » macrostegius Greene.
24. Hespereaea Palmeri A. Gray.
25. Atriplex Palmeri Wats.
26. Erythea edulis Wats.
27. Mimulus latifolius A. Gray.
28. Pogogyne tenuiflora A. Gray.
29. Calamintha Palmeri A. Gray.
30. Senecio Palmeri A. Gray.

## b) Mainland Area.

An examination of the vegetation of this area shows it to be distributed into several distinct formations among which the bog and strand formations are limited in extent owing to the topography of the country. Two territories, the coastal and interior, may be distinguished, separated from each other by the Cuyamaca, Palomar, Temecula ranges.

1) WATSON, S.: 1876, 105—121, see Bibliography p. 87; GREENE, E. L.: Bulletin California Academy Sciences I, 214—228; LYON, W. S.: Bibl. p. 80; compare the subsequent account of the islands of Baja California.

2) "A peculiar species, and by far the most decided shrub of the genus. The three species from this island seem to form a peculiar group by themselves". VASEY, GEORGE and ROSE, J. N.: Contributions U. S. National Herbarium, I: 24.

## 1. Coastal Territory.

### 1. Strand Formation.

Between low and high tide marks, the sandy beach is quite bare of vegetation [1]). However, the rocks of the hills which project into the ocean at Orange County, California, have a large supply of algal growth in this region. *Fucus serrata*, *F. fastigiata*, *Cladophora rupestris*, *Plumaria elegans* and *Corallina officinalis* are the most common sea weeds found here.

Above flood tide, where there is a beach, it is flat and unbroken by dunes. The growth here is almost entirely herbaceous in character. The few woody forms are low and have a spreading habit. *Oenothera cheiranthifolia* var. *suffruticosa* is the common woody form.

Other characteristic species are: Abronia maritima, A. umbellata, Mesembryanthemum aequilaterale, Franseria bipinnatifida and Convolvulus soldanella. It will be noticed that these forms are quite succulent. With the exception of Franseria, all have a spreading or creeping habit. The Abronias are noteworthy in that they have their leaves placed nearly vertically and the leaf surfaces face in different directions. Grasses, which constitute an important part of many strand formations, are here poorly represented. In addition to its own peculiar plants, the strand formation contains a number of species which are present in the more alkaline portions of the mesa. The forms common to both formations are: Salicornia ambigua, Sesuvium portulacastrum, Atriplex californica, Sareobatus Maximiliana and Mesembryanthemum crystallinum. When growing on the coast these forms seem less stiff and hard than when growing inland.

It may be well to contrast those plants confined to the immediate shores of the ocean on the sand of the beach, and those that occur in the tidal marshes, or salt meadows in some places. The following is according to S. B. Parish.

| Arenicolous. | Halophilous. |
|---|---|
| Abronia maritima Nutt. | Astragalus pycnostachys A. Gray. |
| » umbellata Lam. | Atriplex hastata L. |
| Amblyopappus pusillus H. & A. | Batis maritima L. |
| Aphanisma blitoides Nutt. | Jaumea carnosa Less. |
| Atriplex leucophylla Dietr. | Juncus acutus L. Var. |
| » microcarpa Dietr. | Lasthenia Coulteri A. Gray. |
| Calandrinia maritima Nutt. | Monanthochloë littoralis Engelm. |
| Convolvulus soldanella L. | Salicornia ambigua Michx. |
| Franseria bipinnatifida Nutt. | » herbacea L. |
| Mesembryanthemum aequilaterale Haw. | » mucronata Bigel. (= S. Bigelovii Torr.). |
| » crystallinum L. | Scirpus riparius J. & C. Presl. |
| » nodiflorum Haw. | Spartina glabra Muhl. |
| Oenothera viridescens Lehm. | Statice Limonium L. var californica A. Gray. |

1) Mc Kenney, R. E. B.: Notes on plant Distribution in southern California. Botanisches Centralblatt Beiheft Bd. X. Heft 3. 1901.

A small group of plants, according to PARISH[1] enter directly from lower California and inhabit a narrow strip along the coast. Some barely enter this district; a few penetrate some distance within it, and the last one in the accompanying list of such plants disappears at Santa Barbara: Acalypha californica, Agave Shawii, Arctostaphylos diversifolia, Baccharis sarothroides, Beloperone californica, Cereus Emoryi, Dithyrea californica, Frankenia Palmeri, Isomeris arborea, Iva Hayesiana, Mamillaria dioica, Opuntia prolifera, A. serpentina, Simondsia californica and Viguiera laciniata.

## 2. Chaparral Formation.

The most evident characteristic of the coastal territory is the prevalence of oaks. Its rolling hills are covered with open groves of *Quercus Engelmannii* and *Q. agrifolia* associated with *Rhus laurina*. Scrub oak chaparral consists of a growth of *Quercus dumosa*. Two types of this formation may be distinguished, namely, the foothill and mountain types.

*Mountain Facies.* The vegetation of the mountain type consists principally of shrubs with a constant admixture of herbaceous forms. With a few exceptions (*Libocedrus decurrens*, *Pseudotsuga macrocarpa*, *Pinus ponderosa*) trees are absent. The scrub level is commonly between 6 and 9 feet in height.

The following are the most common forms and give the chaparral its general characteristics: Arctostaphylos manzanita, Gilia californica. Audibertia stachyoides, Ceanothus sorediatus, C. cuneatus, C. divaricatus, Quercus dumosus, Quercus chrysolepis, Q. Wislizeni, Castilleja parviflora, Cercocarpus ledifolius, Pentstemon heterophyllus and P. spectabilis. Occasionally some of these forms are found in other formations, but they are not common there and tend to take on a different form of growth. A number of other forms are also met with in the mountain scrub but these are not frequent and are not regarded as migrants from other formations. They do not contribute to the general character of the scrub.

In little isolated patches between the dense scrub masses are found the following characteristic herbaceous forms: Chlorogalum pomeridianum, Zygadenus Fremontii, Gomphocarpus tomentosus, Solidago californica, Epilobium paniculatum and Clarkia pulchella. These forms are not found in masses, but as single individuals, or as small clusters of two or three. When the spaces between the scrub are larger, masses of the following are found: Lupinus affinis, L. truncatus, L. sparsiflorus, L. hirsutissimus, Sanicula arctopoides, Chaenactis artemisiaefolia, Salvia columbariae, Eschscholtzia californica and Viola pedunculata. The last three are very common but are not restricted to this formation. Yucca Whipplei with its short vegetative and enormous inflorescence stems is a very common and typic mountain form. Clambering over the scrub are to be found numerous individuals of Vicia americana var. truncata, Vicia linearis, and to a less extend Convolvulus occidentalis var. tenuissimus and Clematis lasiantha. Even on the top of Mt. Santiago (1,728 meters), the highest peak, these are found in abundance.

*Foothill Facies.* The foothill type is like the mountain type, characterized by a scrub growth. The extent of the scrub is not so great and its nature, both as to composition and structure, is decidedly different from that of the mountains. The scrub varies between 2 and 6 feet in height. Its habit is spreading and open, a marked contrast to the more erect and close grown mountain form. The mountain scrub is social, this is unsocial. As a rule each plant stands by itself and has more or less clear space about it.

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1) PARISH, S. B.: Sketch of the Botany of southern California. Botanical Gazette XXXVI: 261.

Frequently two or three plants cluster together, but these clusters are always surrounded by a clear area [1]).

The leaves of the scrub are almost always very small and entire, commonly linear or lanceolate in shape. In texture they are somewhat leathery. Hairs are present in almost all cases, and are found on upper as well as under leaf surfaces. Often the hairs are glandular. The characteristic forms are: *Eriogonum fasciculatum*, *Artemisia californica*, *Audibertia polystachya*, *Rhamnus crocea* and *Adenostoma fasciculata*. The last two, as mentioned, are occasionally found in the mountains, but it is in the foothill formation that they are abundant.

In many cases cactuses make up a third or even half of the scrub. In some instances the hillsides are covered from base to apex with cactuses. On these the growth is quite tall, often as much as 9 feet (2,5 meters) high. On such hills, even herbaceous growth is largely wanting and the scrub is about equally divided between *Opuntia*, *Eriogonum* and *Artemisia*. The cactus growth is composed of two species — *Opuntia Engelmannii* and *O. prolifera*; the former being twice as common as the latter.

In the open areas about the individuals of the scrub is a large herbaceous vegetation. The composition of this varies at different times of the year. In fact there is a quite regular succession of forms, which begins in the early part of the wet season and continues until the early part of the dry season. From July until the end of the year there is but little change in the herbaceous flora of the foothills. Owing to the grayness of the scrub and the small number of herbaceous forms the hills have a dry dead appearance from July until January. Then owing to the sprouting of members of the first set of herbs, a greener aspect is assumed.

The forms of this first series which are entirely or nearly restricted to the foothills are: Nemophila insignis, N. Menziesii, Plagiobothrys nothofulvus, Gilia dianthoidea, Calochortus albus and Mirabilis multiflora. Brodiaea capitata, Echinocystis fabacea and Eschscholtzia californica, which are also abundant here at this time are found in several formations. In March, the members of the second series attain their full development. These are Layia (Blepharopappus) platyglossa, Madia sativa, Amsinckia spectabilis, Phacelia distans, P. tanacetifolia, Salvia carduacea, S. columbariae, Plantago patagonica var. nuda and Hosackia glaber. During this period, the hills are a blaze of orange owing to the great growth of Cuscuta subinclusa. Almost all of the scrub and often much herbaceous growth is attacked.

During April and early May, the third set of herbs reaches maturity. The characteristic forms are: Allium serratum, Sedum obtusatum, Chorizanthe staticoides, Cnicus occidentalis and Krynitzkia leiocarpa. In late May and June, we find Phacelia hispida, Solanum Xanti, Calochortus catalinae and on the lower parts Nicotiana Bigelovii. By the middle of July the majority of herbaceous forms have fruited and, at least in their aerial parts, hare withered.

Ferns are found more frequently in the foothill formation than elsewhere. They do not, however, constitute a prominent feature of the formation. They frequently have a xerophilous structure. This is particularly true of *Gymno-*

1) Mc Kenney, R. E. B.: loc. cit.

*gramma triangularis* and *Pellaea andromedifolia*. The last, hard to point of brittleness, is the only form in which leaves persist throughout the dry season.

3. Canyon Formation.

The most prominent feature of this formation is the presence of trees. With the exception of the few mentioned in the mountains, trees are restricted to this formation. Trees are not found in all parts of the canyons; but in the parts where they do grow they form groves. It is unusual to find isolated specimens. This social habit does not produce tall straight trunks. Usually the trunks are massive and the unbranched stock is comparatively short. The crown is always large and spreading. These canyon groves are formed almost entirely by two species, namely *Platanus racemosa* and *Quercus agrifolia*. It is as common to find groves consisting of either *Quercus* or *Platanus* as it is to find both together. In the upper and narrower parts of the canyons, *Acer macrophyllum* and *Pseudotsuga macrocarpa* are frequent. *Quercus chrysolepis*, a member of the mountain scrub frequently wanders into the canyons and becomes arborescent.

In the region not occupied by trees, we find numerous shrubs and herbs. The shrubs of the canyon formation are usually taller than those of mountains and foothills and are more regularly branched. The tendency is much more toward a mesophytic than a xerophytic type. The branches are usually straight. The leaves are of medium size and varying shape. They are seldom entire and often compound. The characteristic forms are Eriodictyon tomentosum, Romneya Coulteri, Amorpha californica, Trichostema lanatum, Rosa californica, Mimulus (Diplacus) glutinosus, Photinia arbutifolia, Zauschneria californica, Pentstemon cordifolius. Climbing forms are represented by Vitis californica and Rhus toxicodendron. In canyons which no longer have running water, Opuntia is not uncommon, O. Engelmannii is the common form. It usually takes on the spreading rather than the erect habit and its joints are not more than half the size of the hill forms.

The herbaceous flora of the canyons is a large one but its composition does not vary as often or as regularly as that of the foothills. Many forms are typically mesophytic in nature. In the damper parts Equisetum arvense, E. hiemale, and E. Telmateja, are often to be found. Only one fern growns on the canyon floor, Pteris (Pteridium) aquilina. It is much smaller than when growing in moist open sandy situations.

During the wet season shrubs about 2,5 meters high constitute nearly the entire vegetation of a River Bed Formation. In manner of growth these forms resemble the canyon shrubs. The leaves are, however, always entire and usually smooth. The major portion of this shrub growth is made up of Salix lasiolepis, S. laevigata, Baccharis viminea and Nicotiana glauca. During the wet season, herbs are uncommon and are restricted to the borders of the river beds. After the flow of water ceases (usually in April) many of the mesa herbs spread over the river beds.

## 2. San Jacinto Territory.

This interior territory differs from the coastal mostly in a negative way, the latter possessing fully one hundred species which do not extend into the former. Among these are eight species of *Atriplex*, five each of *Chorizanthe* and *Phacelia*, four each of *Gilia* and *Antirrhinum*, and three each of *Astragalus*, *Calochortus*, *Cotyledon* and *Salvia*.

In the subjoined table, according to PARISH, the species restricted to the interior or coastal territories are displayed.

| Interior. | Coastal. |
|---|---|
| Adiantum capillus-veneris L. | Adiantum emarginatum Hook. (= A. Jordani Muell.). |
| Andropogon macrourus Mich. | Andropogon saccharoides Sw. |
| Antirrhinum glandulosum Lindl. | Antirrhinum Nevinianum A. Gray. |
| Aplopappus linearifolius DC. | Aplopappus ericoides Less. |
| Artemisia Parishii A. Gray. | Artemisia Palmeri A. Gray. |
| Boykinia (Therofon) rotundifolia Parry. | Boykinia (Therofon) occidentalis T. & G. |
| Calochortus Plummerae Greene. | Calochortus Weedii Wood. |
| » splendens Dougl. | » Dunnii. |
| Carex barbarae Dewey. | Carex spissa Bailey. |
| Chorizanthe Fernandina Wats. | Chorizanthe laciniata Torr. |
| » Parryi Wats. | » fimbriata Nutt. |
| Euphorbia ocellata Dur. & Hilg. | Euphorbia misera Benth. |
| Gilia californica Benth. | Gilia floribunda A. Gray. |
| Helianthus Parishii A. Gray. | Helianthus Oliveri A. Gray. |
| Hemizonia (Deinandra) Wrightii A. Gray. | Hemizonia virgata A. Gray. |
| Lathyrus lactiflorus Greene. | Lathyrus splendens Kellogg. |
| Monardella Pringlei A. Gray. | Monardella hypoleuca A. Gray. |
| Opuntia Bernardina Engelm. | Opuntia prolifera Engelm. |
| Phacelia Davidsonii A. Gray var. | Phacelia Douglasii Torr. |
| Ribes glutinosum Benth. | Ribes speciosum Pursh. |
| Zauschneria californica Presl. | Z. californica Presl. var. microphylla A. Gray. |

## 1. Mesa- and Chaparral Formations.

*Mesa Formation.* Stretching between the western or coastal chain of mountains and the interior or San Bernardino range is a slightly elevated and comparatively level plain, commonly called a **mesa**. The mesa formation is characterized by an absence of all arborescent and shrubby growth. Although the vegetation is herbaceous, grasses are uncommon and form an insignificant part of the flora.

The principal species are Datura meteloides, Suaeda Torreyana, Salicornia ambigua, Mesembryanthemum crystallinum, Sesuvium portulacastrum, Eremocarpus setigerus, Sarcobatus Maximiliani, Asclepias eriocarpa, Atriplex patula, A. californica, Heliotropium curassavicum, Euphorbia albomarginata, Croton tenuis, Grindelia robusta, Centaurea melitensis, Cucurbita foetidissima, Malva borealis, Helianthus annuus, Heterotheca grandiflora, Erigeron canadensis, Chenopodium ambrosioides, Eurotia lanata, Trichostema lanceolatum, Nemocaulis Nuttallii, Pterostegia drymarioides, Lastarriaea chilensis and Eriogonum Thurberi. The more succulent forms are commoner on the more alkaline sections of the mesa and the others on the less alkaline soils. Both types tend to

assume a spreading habit[1]. Elsewhere Adenostoma fasciculatum, Prunus ilicifolia, the bushy Pentstemon antirrhinoides, Calochortus Plummerae and Yucca Whipplei abound.

*Chaparral Formation.* Interior southern California is covered with shrubs and trees scattered in open order over plain, hillside and valley. In places (San Diego County) the chaparral consists of *Quercus Engelmannii* which stretches in belts across the hills with *Quercus agrifolia* in park-like growths.

The brush or chaparral is continuous about the base of the San Gabriel Mountains forming thickets far denser and higher than on any area in the neighborhood of the San Bernardino and San Jacinto ranges. In such localities *Arctostaphylos manzanita* and *Ceanothus divaricatus* form an arborescent growth. The common height of the chaparral at middle elevations on the slopes varies from 3 to 4 feet. In the canyons 12 or 14 feet and above the 6,000 feet contour line two feet is a common height. Above the 6,000 foot contour the brush occurs as an undergrowth in the forest.

There is a zonal arrangement of the various species of shrubs. The composition of the chaparral on the southern, eastern and western slopes of San Gabriel Mountains[2] below the 5,000 foot contour is: Adenostoma fasciculatum (65 per cent), Arctostaphylos manzanita (3 per cent), A. tomentosa, Baccharis viminea, Ceanothus crassifolius (1 per cent), C. cuneatus, C. divaricatus (16 per cent), C. hirsutus, C. integerrimus, C. vestitus, Cercocarpus betulaefolius (5 per cent), C. ledifolius (1 per cent), Chrysoma pinifolia, Eriodictyon californicum, E. tomentosum, Fraxinus dipetala, Fremontia californica, Garrya Veatchii, Prunus ilicifolia, Quercus undulata, Rhamnus ilicifolia, R. rubra, Rhus diversiloba, R. trilobata, Ribes cereum, R. hesperium, Salix lasiandra, S. lasiolepis, Aplopappus interior and Styrax californica.

The composition of the chaparral on the southern, eastern and western slopes of the San Gabriel Mountains above the 5,000 foot contour is Adenostoma fasciculatum (40 per cent), Arctostaphylos manzanita (6 per cent), A. patula (10 per cent), A. tomentosa, Artemisia tridentata, Castanopsis chrysophylla, Ceanothus divaricatus (20 per cent), Cercocarpus betulaefolius, C. ledifolius, Fremontia (Fremontodendron) californica, Prunus ilicifolia, Quercus undulata (15 per cent). The chaparral on the northern declivities is very thin and scattered.

In the San Bernardino Mountains[3] the height of the chaparral varies from 3 to 10 feet. It covers all the arid and semiarid lands excepting the areas of the piñon pines. On the Mohave Desert side the brush is in open formation. The chaparral above 4,800 feet exists mostly as underbrush in the forest. The chaparral on the southern and western slopes resembles that of San Gabriel Mountains.

The following species occur in the brush thickets of the San Bernardino range on the eastern slopes below the 5,000 foot contour: Adenostoma fasciculatum (5 per cent), Arctostaphylos glauca, A. tomentosa, Ceanothus cuneatus (2 per cent), C. divaricatus (5 per cent), C. pinetorum, C. vestitus, Cercocarpus betulaefolius (8 per cent), C. ledifolius (10 per cent), Juniperus californica (15 per cent), Quercus undulata (3 per cent) and agaves, cacti and yuccas (50 per cent). If a division be made on the eastern slope at the 3,500 foot contour, the composition of the chaparral would stand:

1) Mc Kenney, R. E. B.: loc. cit.

2) Leiberg, John B.: The San Gabriel forest Reserve. 20th Report U. S. Geological Survey, 1900, Part V: 455—478.

3) Grinnell, Joseph: The Biota of San Bernardino Mountains. Univ. Calif. Publ. in Zool. V: 1—170 (1908); Parish, S. B.: Notes on the Flora of Palm Springs Muhlenbergia III: 121—128.

Juniperus californica (as a shrub 25 per cent); agaves, cacti and yuccas, more or less arborescent 73 per cent and other species, 2 per cent.

San Jacinto Mountain is completely encircled by the chaparral (Upper Sonoran Zone of MERRIAM) which extends from its base to altitudes ranging from 3,000 to 7,000 feet; the upper limit is extremely irregular. Below the 5,000 feet contour on the western side, the growth is quite uniform, broken only by thin lines of oaks, cottonwoods and sycamores, which follow the courses of the streams. Above 5,000 feet the chaparral is not uniform.

Below 5,000 feet on the western slopes occur Adenostoma fasciculatum (50 per cent), A. sparsifolium (25 per cent), Arctostaphylos glauca, A. manzanita, Artemisia tridentata, Baccharis viminea, Ceanothus crassifolius, C. cuneatus, C. divaricatus (8 per cent), C. pinetorum, Cercocarpus betulaefolius (1 per cent), Chrysoma pinifolia, Encelia farinosa, Eriodictyon californicum, E. tomentosum, Garrya Veatchii, Lycium Andersonii, Pentstemon antirrhinoides, Pluchea sericea, Prunus ilicifolia, Quercus undulata (9 per cent), Rhamnus crocea, R. ilicifolius, Rhamnus rubra, Rhus diversiloba, R. ovata, R. trilobata, Ribes sanguineum and Simondsia californica.

Below the 3,500 contour on the eastern slope of San Jacinto Mountains occur Ceanothus cuneatus, C. pinetorum, Larrea mexicana, Dendromecon rigidum, Isomeris arborea, Juniperus californica (60 per cent), Purshia (Kunzia) glandulosa (3 per cent), Quercus undulata (8 per cent). The following herbs are characteristic of this belt: Dicentra chrysantha, Echinocystis macrocarpa, Eschscholtzia californica, Lathyrus violaceus, Hosackia (Lotus) glaber, Pentstemon antirrhinoides, P. spectabilis, Senecio Douglasii and Eriogonum fasciculatum[1].

The chaparral[2] as it occurs at the base and surrounding the San Gabriel, San Bernardino and San Jacinto mountains is such by reason of climatic conditions. It does not owe its origin to the destruction of pre-existent forest and subsequent deficient reforestation. The shrubs which compose it are such as are adapted to semiarid environments and if at any time in the past forests covered the chaparral areas, it was at a period so remote that no trace of such forests exist at the present time.

## 2. Forest Formations.

The forest growth in the San Gabriel, San Bernardino and San Jacinto mountains presents three general types, namely, the semiarid, subhumid and humid.

*Semiarid Forest Belt.* The principal species of the semiarid type in the San Gabriel Mountains are: *Alnus rhombifolia*, *Cercocarpus betulaefolius*, *C. ledifolius*, *Fremontia californica*, *Juniperus californica*, *Pinus attenuata*, *P. Coulteri*, *P. monophylla* (4 per cent), *Platanus racemosa*, *Pseudotsuga macrocarpa* (80 per cent), *Quercus californica* (= *Q. Kelloggii*), *Q. chrysolepis*, *Q. Wislizeni* and *Yucca arborescens*. The forest of the semiarid tracts of the San Bernardino Range is essentially composed of stands of *Pinus monophylla*. — The thin lines and groups of trees of other species which occur

1) HALL, H. M.: See Bibliography p. 76.

2) LEIBERG, J. B.: See Bibliogr. p. 76; BARBER, JOHN H.: A Glimpse of the San Gabriel

on the western and southern slopes in the chaparral formation are due to local conditions of moisture supply, such as streams, springs, etc.

The species which enter into this type of forest are below the 6,500 foot contour and their percentages: Cercocarpus ledifolius (as tree), Juniperus californica (as tree 4 per cent), Juniperus occidentalis (1 per cent), Pinus monophylla (93 per cent) and Yuccas (2 per cent), while above the 6,500 foot contour the following trees are found: Abies concolor (10 per cent), Cercocarpus ledifolius (15 per cent), Juniperus occidentalis (25 per cent), Pinus monophylla (38 per cent), Pinus ponderosa (10 per cent), with yuccas and scattering oaks forming two per cent. The composition of this type of forest in the San Jacinto Mountains is on the eastern slope where the piñon belt (Pinus monophylla Facies) begins at an elevation of 2,500 feet: Pinus monophylla (99 per cent), Fraxinus velutina (= F. pistaciaefolia), Populus trichocarpa, Quercus californica (Q. Kelloggii), Q. chrysolepis, Salix lasiandra and Yucca arborescens, while on the southern and western slopes are found Pinus monophylla (8 per cent), Pinus quadrifolia (90 per cent), Quercus chrysolepis, Q. Wislizeni, Populus trichocarpa, P. Fremontii and Salix lasiandra. Between the 3,500 foot and the 4,800 foot contour lines the stands attain their maximum density. On the San Jacinto range the growth thins out and soon ceases above the 4,800 foot contour.

*Subhumid Forest Belt.* The second type of forest covers subhumid tracts. The growth is open and park-like, consisting in the San Gabriel Mountains between the 5,500 foot and the 9,000 foot contours of *Abies concolor* (25 per cent), *Libocedrus decurrens* (3 per cent), *Pinus attenuata*, *P. Coulteri*, *P. flexilis* (1 per cent), *P. Lambertiana* (6 per cent), *P. monophylla*, *P. ponderosa* (20 per cent), *Pseudotsuga macrocarpa* (40 per cent). In the San Bernardino Range the subhumid type is best developed between 5,000 and 9,500 feet and it is of an open character. The composition of the forest between the 3,000 foot and the 6,000 foot contour is formed by: *Abies concolor* (6 per cent), *Pinus ponderosa* (64 per cent), *Pseudotsuga macrocarpa* (14 per cent), *Quercus* (3 species) and other trees, while between 6,000 and 8,500 feet occur *Abies concolor* (30 per cent), *Libocedrus decurrens* (4 per cent), *Pinus Coulteri*, *P. Lambertiana* (8 per cent), *P. Murrayana* (1 per cent), *Pinus ponderosa* (52 per cent), occur with *Pseudotsuga* and oaks (*Quercus californica*, *Q. chrysolepis* 3 per cent). The oaks thin out and disappear at 8,000 feet, as do the alders, sycamores and willows at short distance above the 6,000 foot contour line.

*Pinus ponderosa Belt.* In the San Jacinto Mountains the *Pinus ponderosa* type of forest is developed between 5,000 and 9,000 feet. Between the 6,000 and 8,500 foot contours the following trees are found: *Abies concolor* (30 per cent), *Libocedrus decurrens* (8 per cent), *Pinus Lambertiana* (25 per cent), *P. Murrayana* (5 per cent), *P. ponderosa* (30 per cent), *Quercus californica* (= *Q. Kelloggii*), *Q. chrysolepis* and *Cercocarpus ledifolius*.

This forest is largely free from undergrowth, but we find in the higher valleys Symphoricarpos Parishii, Pentstemon Rothrockii, and in the lower part of the pine belt are Arctostaphylos Pringlei var. drupacea, Ceanothus integerrimus, Rhamnus californica var. tomentella, Cornus Nuttallii, and others. In the last end of Tahquitz Valley in the San Jacinto Mountains patches of Amorpha hispidula and Garrya Fremontii are not rare beneath the pines. The herbaceous vegetation is more abundant and varied in the pine woods. Here grow Pentstemon labrosus, Monardella lanceolata, Streptanthus campestris, Arabis arcuata, Euphorbia Palmeri, Frasera Parryi, Hosackia nevadensis and Pedicularis semibarbata.

*Humid Forest Belt.* Lying above the 9,000 foot contour line in the San Gabriel Mountains on a few summits and slopes occur *Abies concolor* (35 per cent), *Pinus flexilis* (15 per cent) and *Pinus Murrayana*. These trees form an open forest, with scanty and low underbrush, which is broken by bare, rocky expanses. This humid type of forest in the San Bernardino Mountains between elevations of 8,500 feet and 11,500 feet is composed of *Abies concolor* (45 per cent), *Libocedrus decurrens* (2 per cent), *P. Murrayana* (35 per cent) and other pines. This belt represents in its relative position, if not wholly in species, the alpine-fir type of the forests north of California.

Between 9,500 and 11,500 feet the following is the composition of the forest: Abies concolor (8 per cent), Pinus flexilis (50 per cent), P. Lambertiana (1 per cent), P. Murrayana (40 per cent), P. ponderosa (1 per cent).

In the San Jacinto range at 9,500 feet the following trees mostly disappear: Abies concolor, Libocedrus decurrens, Pinus Lambertiana, P. ponderosa. The sugar pine, Pinus Lambertiana persists as low, stumpy trees two to three hundred feet above 9,500 feet. At this elevation, Pinus Murrayana and P. flexilis begin to grow. The increase rapidly in numbers and above 9,800 feet, they constitute nearly the entire arborescent growth.

The greater part of this belt corresponding with the Canadian and Hudsonian zones of MERRIAM is characterized besides the trees previously mentioned by the presence of Carex Hallii, C. nebraskensis, Montia Chamissonis, Poa alpina, Silene Parishii, Stellaria (Alsine) crispa and Viola blanda.

### 3. Meadows, Stream Plants and Alpine Crests.

*Meadow Formation.* Meadows of various sizes are scattered over the San Jacinto Mountains between the altitudes of 4,000 and 10,000 feet. Wherever the water rises to the surface, the coniferous forest is replaced by a meadow.

The vegetation of the smaller hillside meadows consists largely of true grasses such as *Agrostis tenuis* and *Sporobolus gracillimus* which predominate with a species of *Bromus* on the margins.

Associated with the grasses, according to HALL[1]) are, Sisyrinchium bellum, Mimulus primuloides, M. Langsdorfii var. Tilingii and Rumex salicifolius. Wire grass Juncus mexicanus enters largely into the composition of certain meadow floras and where the water rises nearer the surface, appear Agropyrum caninum, Elymus triticoides and Polypogon monspeliensis. In boggy hillsides meadows between 6,000 and 9,000 feet grow Agrostis tenuis, Phleum alpinum, and where the soil contains but a moderate amount of moisture, Elymus glaucus and Bromus marginatus, while Glyceria nervata lines the creeks below 7,500 feet altitude. In Round Valley, at an altitude of 9,000 feet occurs a meadow unlike others, for here under the same edaphic conditions Carex Hallii and C. nebraskensis replace the grasses except Poa alpina.

The streams in Strawberry and Onstatt valleys, San Jacinto range, are lined with a Riparian Formation of Alnus rhombifolia, Salix lasiolepis, S. laevigata, and in the canyons Rhododendron (Azalea) occidentale and Cornus pubescens. Many herbs are found in the moist soil and under deep shade along streams: Lilium Parryi, Habenaria leucostachys, Epipactis gigantea and Smilacina amplexicaulis, Aquilegia truncata, Castilleja miniata, Epilobium glaberrimum and Hosackia oblongifolius.

There exists on San Jacinto Mountain under xerophytic conditions with low temperature and dry soil in the crevices of rocks a Crest Formation where

the moisture drains rapidly away. *Cercocarpus ledifolius*, *Spiraea* (*Holodiscus*) *discolor* var. *dumosa*, *Philadelphus serpyllifolius*, *Aplopappus cuneatus*, *Ceanothus cordulatus* and *Arctostaphylos patula* grow in such situations besides *Eriogonum saxatile*, *Silene Parishii*, *Gilia pungens* and *Hieracium horridum*.

*Alpine Formation*. The most southern latitude at which the true boreal alpine plants exist in North America is on San Jacinto Mountain, where are found a few characteristic species growing along the banks of perpetual snow in the cool, shaded canyons, which descend the north side of the main peak at altitudes of between 10,000 and 10,800 feet.

The plants of the summit of San Jacinto Peak (10,700—10,805, 10,987) feet altitude = 3290 m) are: Aquilegia truncata (alpine form), Carex Preslii, Castanopsis (Castanea) chrysophylla, Draba corrugata, Heuchera rubescens, Holodiscus discolor var. dumosa, Monardella odoratissima, Oxyria digyna, Pedicularis semibarbata, Pinus flexilis, P. Murrayana, Ranunculus Eschscholtzii, Ribes cereum, R. lacustre var. molle, Silene Parishii, Spraguea umbellata, and Trisetum subspicatum[1].

We know that on Grayback Peak *Pinus albicaulis* makes its appearance at 11,500 feet and continues alone nearly to the summit 11,725 feet (= 3574 m) above sea-level. The summit of Grayback is flat and consists of porous decomposed granite unfavorable to the growth of plants. San Jacinto is more fortunate having on its precipitous northern face some steep, shaded canyons preserving perpetual snows. Nevertheless, the flora of these high peaks is scantier than their altitude would lead one to expect. A single species *Ranunculus Eschscholtzii* has been found on both peaks, *Arenaria* (*Alsine*) *verna* var. *hirta* and *Antennaria alpina* have been collected on Grayback, while from San Jacinto *Carex Preslii* and *Oxyria digyna* have been added to the short list[2]).

# Chapter V. Mexican Subtropic Zone and Mountain Regions.

Within this zone are several regions which have been included in the temperate zone. The distinction is somewhat difficult to draw between the flora of temperate and tropic climates, because of the fact that many plants range north or south of their usual limits by taking advantage of mountain summits, or river valleys.

## 1. Sonoran Desert Region.

This comprises the desert region lying contiguous to the valleys of the lower Rio Grande and Gila rivers and immediately surrounding the shores of the Gulf of California. The geology, physiography (ante p. 113) and climatology (ante p. 148) have been described previously in detail. Three districts are recognizable and are described below.

1) Hall, H. M.: Loc. cit. page 33.
2) Parish, S. B.: See Bibl. p. 81.

## A. Yuman District.

This district includes the Colorado Desert, which occupies a great valley, or depression, 180 miles (280 km) long and 30 to 50 (50—80 km) wide, the valley of the Gila River and the country south of the plateau coincident with the New Mexican-Arizonan deserts previously described (ante p. 574). It includes the delta country of the lower Colorado River. The vegetation of these deserts as noted before (p. 585) is of the most varied components. THORNBER has tabulated the various desert species from the standpoint of habitat and vegetation forms, and if one views the desert landscape consisting of Tumamoc Hill, where the desert laboratory is situated, the mesa-like mountain slopes, the floods plains about Tucson, Arizona, he sees the plants species numerically as follows: trees 15; shrubs 39; woody twiners 5: dwarf shrubs 17; half shrubs 32; perennial herbs 108; biennial herbs 3; long-lived annual herbs 57; winter annuals 122; summer annuals 44; algae 7, a total of 449 distinct species [1]).

*Desert Formation.* The woody vegetation of the desert in the vicinity of Tucson, Arizona consists of *Larrea mexicana* (= *Covillea tridentata*), several species of *Opuntia*, *Ephedra trifurca*, *Prosopis juliflora*, *Acacia Greggii*, *Cereus* (*Carnegica*) *giganteus* (upon the foothills), *Parkinsonia microphylla*, *P. Torreyana*, *Fouquiera splendens*, and two species of *Lycium*, such as *L. Fremontii.*

A large number of species with perennial root-stocks and bulbs push up shoots, leaves and flowers under the stimulus of the rising temperature and moisture supply. Such vegetation awakens in January, blooms early in February and matures fruit in March and April. Such winter perennials are Brodiaea capitata, Anemone sphenophylla, Pentstemon Wrightii, P. Parryi, Hilaria mutica, Cassia Covesii, Franseria deltoidea, Encelia farinosa, Covillea tridentata, Baileya multiradiata, and Calliandra eriophylla. Among the winter annuals near Tucson which spring from germinating seeds in the wet winter season and soon form fruit and seed for the next growth are species of Astragalus, Harpagonella Palmeri, Pectocarya linearis, Plantago, Phacelia, Amsinckia, Daucus, Bowlesia, Eremiastrum, Microseris, Eschscholtzia mexicana, according to the observations of MAC DOUGAL. The spinose and succulent forms of the early, dry summer are Echinocereus Fendleri, Opuntia versicolor, O. spinosior, O. fulgida, O. Bigelowii. The hillsides are yellow with the flowers of Parkinsonia microphylla and P. Torreyanus, while the desert here is characterized also by summer perennials, summer annuals and plants of the dry after summer.

River Bank Formation. The banks of the Agua Fria River [2]) and its tributaries in the desert region of central Arizona were in many places covered with large clumps of Prunus demissa, Rhamnus californica, Platanus racemosa, Fraxinus velutina (= F. pistaciaefolia), Juglans californica, covered with vines of Vitis arizona. In many places, the river bed was a complete tangle of Fallugia paradoxa, Baccharis glutinosa and salicina.

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1) SPALDING, V. M.: Distribution and Movements of desert Plants. Publ. 113 Carnegie Institution of Washington. 1909; MENDENHALL, W. C.: Some desert watering Places in S. E. Calif. and S. W. Nev. U. S. Geol. Surv. Water Supply Paper No. 224; STANDLEY, PAUL C.: Notes on the Flora of the Pecos River National Forest; Muhlenbergia V: 17—30; MAC DOUGAL, D. T.: The Course of the vegetative Seasons in southern Arizona. The Plant World, Sept., Oct., Nov., Dec. 1908.

2) TOUMEY, J. W.: A Bit of the Flora of central Arizona. The Botanical Gazette XVII: 162—164.

Chaparral Formation. A chaparral of oaks extends back to the mountains. It is composed of Quercus undulatus mixed with Arctostaphylos tomentosa, A. nevadensis, A. pungens, Acacia Greggii, Zizyphus lycioides, while underneath were growing Hedeoma Drummondii, Verbena ciliata, Mentzelia Wrightii, Hilaria rigida, Bouteloua racemosa, Muhlenbergia texana, and several species of Eriogonum. Here and there were Yucca baccata and Agave Parryi.

*Canyon Formation.* The canyons which cut into the Colorado Plateau and are open to the desert below are distinguished by the presence of *Quercus Emoryi*, *Alnus oblongifolia*, *Platanus racemosa* and on the steep slopes *Juniperus californica* var. *utahensis*, *J. pachyphloea*, *Pinus monophylla* and *Canotia holocantha.* Higher the canyon sides are lined with *Aquilegia chrysantha* associated along the banks with *Nicotiana attenuata*, *N. trigonophylla*, *Mimulus luteus*, and many perennials. Higher still where the canyon stream is shut in by almost perpendicular walls of rock, grow *Mimulus cardinalis*, *Mirabilis multiflora*, *Heuchera parviflora* and *Pteris aquilina* in large masses.

The Foothill Formation consists of an association of *Larrea mexicana* (= *Covillea tridentata*), which grows west of the Colorado river bottom in the gravel hills with *Fouquiera splendens*, *Olneya tesota*, *Prosopis juliflora* (occasional) and *Parkinsonia Torreyana*, *Agave*, *Nolina*, *Dasylirion*, *Opuntia* species and *Eurotia lanata*. If we ascend the foothills, on which grow *Juniperus monosperma* and *Pinus edulis*, during the dry season, we encounter *Dicoria Brandegei*, *Oxytenia acerosa* [1]), *Tetradymia canescens*, *Yucca baccata* and *angustifolia*, *Mamillaria vivipara*, *Cereus Engelmannii*, *Opuntia basilaris*, *Ephedra antisyphilitica*, while in the wet season are found *Lupinus capitatus*, *Mirabilis multiflora*, *Riddelia tagetina*, *Zinnia grandiflora*, etc.

The natural cattle ranges of the valleys and valley slopes were occupied by Eriochloa polystachya, Chloris elegans, Eragrostis neo-mexicana, Panicum obtusum, Chaetochloa composita, Bouteloua oligostachya, B. polystachya, Andropogon Torreyanus, Hilaria mutica and H. Jamesii associated with Plantago fastigiata, while the most important grasses on the open mesa range are Hilaria mutica, H. Jamesii, H. cenchroides, Bouteloua oligostachya, B. polystachya, B. eriopoda, B. curtipendula, Pappophorum Wrightii and in depressions where the water accumulates after summer rains are Chloris elegans, Eriochloa polystachya, Panicum obtusum, P. colonum, Andropogon Torreyanus, Eragrostis neo-mexicana. The grasses found on the sandy portions of the river bottoms are: Sporobolus cryptandrus and Chaetochloa composita.

The mountain range [2]) presents a characteristic appearance because the higher elevations receive a more liberal supply of moisture. Here without forming a sod are found Andropogon contortus, A. leucopogon, Elionurus barbiculmis, Bouteloua bromoides, B. oligostachya, B. curtipendula, Triodia mutica, Eragrostis lugens, Muhlenbergia gracillima, M. Porteri and Epicampes rigens.

Desert Sand Hill Formation. On dry sand hills of the desert grow *Coldenia Palmeri*, *Psathirotes annua*, *Hyptis Emoryi*, *Triodia pulchella*, *Eriogonum inflatum*, *Chorizanthe rigida*, *Mamillaria barbata*. On stony declivities are found *Larrea*, *Yucca brevifolia*, *Atriplex canescens*, *Opuntia ramosissima* and *Echinocactus cylindraceus*.

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1) PHILLIPS, F. J.: A Study of Piñon Pine. Bot. Gaz. XLVIII: 216—223.

2) GRIFFITHS, DAVID: Range Improvement in Arizona. U. S. Bureau Plant Industry Bulletin 4: 23.

The alkali playas, or flats, are characterized by Allenrolfea (Spirostachys) occidentalis and Suaeda, Distichlis spicata, Phragmites phragmites, Juncus Cooperi. In some of the moister places occur Scirpus Olneyi and Tessaria borealis.

To be considered here is a palm Washingtonia (Neowashingtonia) filifera which grows in groves in the canyons formed by the timberless spur which juts eastward from the San Bernardino Mountains[1]) in broad deltas of gravel. The palms grow on clay soil incrusted with alkali, but their roots receive the water which falls, as rain, on the mountains sinks into the earth and percolates down to the foot of the hills. These areas are marked by the presence of plants characteristic of alkaline springs. Besides the palm occur Prosopis juliflora, Distichlis spicata, Epipactis gigantea, Parosela spinosa, Peucephyllum Schottii. Elsewhere on this desert grow Yucca mohavensis, Opuntia Bigelowii, O. echinocarpa, O. basilaris and Audibertia (Ramona) polystachya.

*Delta Sand Mound Formation.* The arid region of the Colorado Delta extending southward from the Gila River consists principally of long gentle slopes or sandy gravelly plains rising gradually toward the interior and broken here and there by a series of low mountain ranges. Mounds of sand are found held together by the roots of *Ephedra*, *Larrea* and other shrubs[2]). In addition to the few herbaceous types which arise during the season favorable for their growth, the principal types are perennials with spinose branches and reduced deciduous leaves such as *Franseria albicaulis*, *Lupinus mexicanus*, *Abronia villosa*, *Astragalus Vaseyi*, *Plantago scariosa*, *Gilia Schottii*, *Stillingia annua*, *Asclepias subulata*, *Hesperocallis montana* (with perennial bulbs) and *Fouquiera splendens*.

The delta consists of an alluvial plain not more than 12 feet (4 m) above the low water mark. The banks of the river are subject to erosion and are constantly shifting. Almost pure associations of willow and poplar, Populus mexicana, cover extensive areas. Large areas are also covered by Pluchea sericea, mesquite (Prosopis velutina) and screw-bean (P. pubescens). Phragmites fringes the channel in the upper part of the delta and two or three species of Atriplex are found in sections where the action of the river prevents the establishment of woody perennials of larger size. Typha angustifolia grows in the lower part of the delta where the river is affected by the spring tides in dense masses lining the shore for many miles. The willows extend farthest toward salt water. Beyond these are mud plains covered with salt grass (Distichlis spicata) and Cressa truxillensis with small clumps of Atriplex, Prosopis velutina and P. pubescens.

In other places, according to MAC DOUGAL[3]), the arrow-weed (Pluchea sericea), quelite (Amaranthus Palmeri), wild hemp (Sesbania macrocarpa), salt-grass and wild rice (Uniola Palmeri) occur in considerable density. Filling the spaces between the colonies of these plants grow the mesquite and screw-bean Phragmites, Scirpus, cow pumpkin (Cucurbita palmata) and others.

## B. Sinaloan District.

This district occupies that part of Mexico lying between the Gulf of California and the Sierra Madre Mountains and extending south almost to the twenty fifth degree of latitude, just north of Mazatlan. The prevailing

1) COVILLE, F. V. and MAC DOUGAL, D. T.: See Bibliography p. 75.

2) MAC DOUGAL, D. T. (1904): See Bibl. p. 77; SNOW, FRANK J., HILGARD, E. W., SHAW, G. W.: Lands of the Colorado Delta in the Salton Basin. California Agricultural Experiment Station. Bulletin 140 (1902); MAC DOUGAL, D. T.: Across Papagueria. Bull. Amer. Geogr. Soc. XL. Dec. 1908.

3) Botanical Features of North American Deserts. Publication 99. Carnegie Institution 1908: 33.

vegetation is perennial and of slow growth, stunted in aspect. It is not distributed uniformly, but arranged in separate tufts or clumps, gathering into a nearly continuous mantle in wetter spots. The arborescent vegetation is of two types, viz., (1) trees and shrubs allied to those of humid lands, but modified to fit arid conditions; and (2) distinctive forms, evidently the result of desert conditions. The prevailing tree is *Prosopis juliflora* which on the alluvial fan of the Rio Sonora grows with remarkable luxuriance, dominating elsewhere the plains and pushing well up into the canyons. Associated with it are *Olneya tesota*, *Acacia Greggii* and on Tiburon Island in similar associations occurs *Parkinsonia Torreyana*. The ocotilla *Fouquiera splendens* is also abundant in all places, except rocky slopes, while the higher plain slopes show such pulpy stemmed shrubs as *Jatropha cardiophylla*, *J. spathulata* and *Bursera microphylla*.

Along the lower stretches of certain rivers grow *Guaiacum Coulteri* and *Jacquinia pungens* with *Caesalpinia gracilis* on the flanks of gorges in the shelter of more vigorous shrubs, as likewise *Sebastiana bilocularis*. The lower extremities of sand washes, wet only in times of flood, are characterized by *Hymenoclea monogyra* which shrinks to stunted tussocks after a year or more of drought. *Phragmites communis* forms cane brakes also here about all permanent waters [1].

The coasts of Sonora both insular and mainland are skirted by strips of shrubbery maintained by fog moisture. Along the mountainous parts of the coast the strip is narrow and indefinite, but on the plains, it extends inland for several miles. *Celtis pallida*, *Maytenus phyllanthoides* and *Frankenia Palmeri* are characteristic shrubs. *Cereus* (*Pachycereus*) *Pecten aboriginum* (see Fig. 9 p. 297), *Larrea* (*Covillea*) are found in the neighborhood of Guaymas. The salt waters of Guaymas Harbor and other bays along the coast are characterized by *Rhizophora mangle* (see colored map) and *Avicennia nitida* in proximity to such desert plants as *Cereus Thurberi* and *C.* (*Pachycereus*) *Pringlei* [2]. — On many of the higher plain slopes especially inland there are found pulpy stemmed shrubs and trees such as *Jatropha* and *Bursera*, on others *Yucca*, *Nolina*, *Dasylirion* with agaves in evidence.

The mountain sides near the Gulf of California show the presence of Acacia Willardiana with which is associated Ficus Palmeri springing from the walls and crests of cliffs along rocky barrancas near a permanent water supply. Interspersed among the larger trees and spreading over the intervening spaces particularly in the drier and more saline spots grow thorny shrubs of the genera Cassia, Microrhamnus, Celtis, Randia, Stegnosperma, Krameria, Frankenia and Acacia, while considerable tracts are sparsely occupied by Larrea. Various cacti are intermixed with the above plants viz., Cereus giganteus, C. Pringlei, C. Thurberi, C. Schottii, Echino-

1) Mc Gee, W. J.: The Seri Indians, 17th Report, U. S. Bureau of Ethnology: 31—36.

2) Since this book went to press, there has been great activity in the study of the Cactaceae by American botanists, compare Schumann, Karl: Gesamtbeschreibung der Kakteen (1899); Berger, 16th Rep. Mo. Bot. Gard.; Britton, N. L. and Rose, J. N.: Cereus and its Allies in North America, Contr. U. S. Natl. Herb. XII: 413—437; Safford, W. E.: Cactaceae of northeastern and central Mexico (illustrated), Annual Report Smithsonain Institute 1908: 525.

cactus Wislizeni, E. Lecontei (three to six feet high), Opuntia fulgida. At an elevation of 800 feet on the plain in which stands Torres, the most conspicuous vegetation is composed of Olneya tesota, Cereus (Lemaireocereus) Thurberi, C. (Lophocereus) Schottii, Parkinsonia microphylla, Guaiacum Coulteri, Acacia farnesiana, Randia Thurberi and several malpighiaceous and other woody vines which associate themselves with clumps of the trees and shrubs. Maximowiczia sonorae, a cucurbitaceous tendril-bearing plant with enormously thickened root and stem base occurs beneath some supporting shrub. Westward from Torres, according to COVILLE and MAC DOUGAL, the line of hills is approached beyond which the country drops toward the coastal plain.

## C. Lower California District.

### 1. The Peninsular Territory.

Lower, or Baja California is a peninsula situated between the Gulf of California on the east and the Pacific Ocean on the west. Phytogeographically the peninsula may be looked upon as a distinct district, its flora having exceptionally strong affinities with that of Sonora, for out of 732 species, 500 species are North American. At one time the peninsula may have been an island separated from the northern mainland by a wide sheet of water for some distance south of the mouth of the Colorado River mud flats and saline plains exist, south of which come the volcanic and granitic mountains.

This district, which has a wet season (June to September), and a dry season, is quite thickly covered with large bushes, small trees and an abundance of climbing and twining plants. Certain trees increase in size in going southward, viz., *Lyrocarpa Xanti*, *Aplopappus spinulosus*, *Aster spinosus*, *Bebbia juncea*, while *Atamisquea emarginata*, *Schoepfia californica* and *Maytenus phyllanthoides* decrease in size. *Prosopis juliflora* is also abundant. The extreme southern, or cape region of lower California is characterized by the following cacti: *Mamillaria Goodridgii*, *Cereus pecten aboriginum* (see Fig. 9 p. 297), *C. Pringlei*, *C. (Wilcoxia) striatus*, *C. (Lemaireocereus) gummosus*, *C. Schottii*, *C. Thurberi*, *Opuntia prolifera*, *O. rotundifolia*[1]).

The spring-flowering plants are Abutilon californicum, Caesalpinia placida, Acacia farnesiana, A. Wrightii, Cereus pecten-aboriginum, C. Pringlei, C. Schottii, C. Thurberi, Diodia crassifolia, Pluchea odorata, Buddleia crotonoides, Samolus ebracteatus, Euphorbia Xantii, while Perityle crassifolia, Fouquiera spinosa, species of Justicia, Beloperone, Calliandra, Dalea, Tephrosia, and Viguiera flower throughout the entire year. The plants here mentioned come into flower with the advent of the rainy season: Desmodium, Lopezia, Begonia, Oenothera, Mitrocarpum, Stevia, Valeriana, Cyclanthera, Carminatia, Baccharis, Bidens, Verbesina, Heterospermum, Dysodia, Tagetes, Buchnera, Clevelandia, Mirabilis and Dicliptera[2]).

The sandy and gravelly lower coastal slopes near San Felipe Bay furnish suitable conditions for Lycium Torreyi, Dalea spinosa, Asclepias subulata (in clumps), Argyrothamnia serrata, Ibervillea tonella, Croton californicus, Lupinus mexicanus and Frankenia Palmeri. The low alkaline pockets reached by the spring tides furnish suitable edaphic surroundings for Spirostachys

1) BRANDEGEE, T. S.: Cactaceae of the cape Region of Baja California. Zoe II: 18; Field Notes on the Plants of Baja California, Zoe II: 145.

2) BRANDEGEE, T. S.: The Distribution of the Flora of the Cape Region of Baja California Zoe III: 223—231.

occidentalis[1]). The sands of the seashore from Todos Santos to San Jose on the Pacific side of the most southern extremity of the peninsula abound in Euphorbia leucophylla and Ipomoea pescaprae, while elsewhere as beach plants grow Dalea maritima, Perityle crassifolia, Palafoxia arenaria, Rhachidospermum mexicanum, Hofmeisteria fasciculata and Stegnosperma halimifolia. The lagoons near La Paz are characterized by sub-tropic maritime brackish-water plants, such as Conocarpus erectus, Avicennia nitida, Ipomoea acetosaefolia, Laguncularia recemosa, Scaevola Plumieri, Samolus ebracteatus and Centunculus minimus. At an elevation of 3,000 feet (1000 m), southwestward of San Felipe Bay, the granite slopes support a sparse vegetation of Bursera micropbylla, Asclepias albicans, Eriogonum inflatum and species of Mammillaria, Ephedra, Yucca, Agave and Opuntia. Two palms are abundant along streams on the eastern slopes of the higher mountains, viz., Washingtonia sonorae and Erythea arctuata.

The most interesting feature of the district however, consists in the great number of mud volcanoes covering an area of about two square miles on the southern shore of Volcano Lake. These are in an active state and the soil near them is highly charged with saline matter and sulphur. *Sesuvium portulacastrum* is abundant in places, but extensive areas here are absolutely devoid of vegetation.

San Pedro Martin Mountain, situated about 125 miles southeast of San Diego, is an extensive and elevated plateau, having an elevation of 7—8000 feet and traversed by numerous rocky ridges 2000 or 3000 thousand feet higher. Northern plants, favored by the climate, which is cold in winter and with a rainfall greater than in the lowlands reach the middle portion of Lower California. Trees of good size are found almost over the whole plateau. *Pinus ponderosa* var. *Jeffreyi* forma *peninsularis* is the most common, but on the ridges a few sugar pines (*Pinus Lambertiana*) and along streams some cedars (*Libocedrus decurrens*) keep them company. In a few localities *Populus tremuloides*, *Cupressus guadalupensis*, *Abies concolor* can be found, but they are not common and at lower elevations *Pinus Parryana* is almost the only tree. Oaks, (*Q. agrifolia*, *Q. Wislizeni*, *Q. chrysolepis*, *Q. grisea*, *Q. dumosa*), are plentiful, *Garrya*, *Ceanothus cordulatus* and *Rhamnus californica* are common, with plants of genera which belong to a temperate climate and are found only on the high mountains[2]).

## 2. The Insular Territories.

The flora of the islands of the coast of lower California is of considerable interest. San Pedro Martin Island has three endemic species: *Hofmeisteria laphamioides*, *Pelucha trifida* and *Perityle Emoryi*. Raza Island is exceptionally rocky, except a few low areas. Upon this island grow *Opuntia tunicata*, *O. echinocarpa*, *Sesuvium portulacastrum*, *Salicornia ambigua*, *Atriplex dilatata* and *A. insularis*. The flora of Carmen Island, one of the largest, is almost identic with that of the peninsula and may be neglected here[3]). The plants

1) MacDougal, D. T.: Delta and desert Vegetation. Botanical Gazette XXXVIII: 44—63 July 1904.

2) Brandegee, T. S.: Southern Extension of California Flora. Zoë IV: 199—210.

3) Vasey, G. and Rose, J. N.: See Bibl. p. 86. Greene, E. L.: See Bibl. p. 83.

peculiar to Magdalena and Santa Margarita Island are *Gongylocarpus fruticulosus*, *Mamillaria Halei*, *Agave Margaritae*, *Brickellia hastata*, *Viguiera subincisa*. — Cedros (Cerros) Island is the largest of the Mexican coast islands. Here grow *Pentstemon cedrosensis*, *Mentzelia cordata*, *Gilia Veatchii*, *Harfordia fruticosa*. On the slopes of the mountain are found such shrubs as *Mimulus glutinosus*, *Sphaeralcea fulva*, *Oenothera arborea* and *Juniperus cerrasianus*, while the mountain summit is adorned with open groves of *Pinus muricata* associated with *Arctostaphylos bicolor*, *Eriogonum molle* and *Senecio cedrosensis*. The elephant tree inhabits all parts of the island, but more especially the arroyos or ravines. In all 135 species of plants are known from this island and many of them are peculiar.

The San Benito islands lie seaward some twenty miles west of Cedros Island and consist of three islets. Only a limited number of plants are known from the islands and comparing these with other islands nearby, it is found that the flora of the San Benitos shows a closer relation to that of Guadalupe Island (see ante p. 623), one hundred miles seaward, than to Cedros Island near at hand. The following are the plants recorded[1]:

| | | |
|---|---|---|
| Eschscholtzia ramosa Greene. | Atriplex deltata Greene. | Perityle Greenei Rose. |
| Lepidium lasiocarpum Nutt. | Mamillaria Goodrichii Scheer. | Krynitzkia maritima Greene. |
| Lavatera venosa Wats. | Mesembryanth. crystallinum L. | » ambigua A. Gray. |
| Frankenia Palmeri Wats. | Encelia conspersa Benth. | Trixis angustifolia DC. |
| Hosackia maritima Nutt. | Viguiera lanata A. Gray. | Lycium californicum Nutt. |
| Cotyledon linearis Greene. | Hemizonia Streetsii A. Gray. | Plantago patagonica Jacq. |
| Euphorbia benedicta Greene. | Amblyopappus pusillus Hook. & Arn. | Mirabilis californica A. Gray. |
| Calandrinia maritima Nutt. | | Brodiaea capitata Benth. |

## 2. Western Sierra Madre Region.

The mountains of this region run in a general northwest and southeast direction, but are not a uniform chain, being broken into a confused mass of peaks and ranges separated from each other by deep valleys and impassable canyons and barrancas.

Formations in Central Sierra Madre Mountains. Journeying on the pine clad highlands, the traveller finds nothing to remind him that he is in southern latitudes except an occasional glimpse of an *Agave* between the rocks and the rarer cactaceous species. Species of *Opuntia*, *Echinocactus* and *Mamillaria* are found here and there, but form no conspicuous feature in the higher altitudes of the sierra.

### 1. Hills and Table Lands.

*Pine-Oak Forest Formation.* The hills and table lands are pine covered at an approximate elevation of 7,400 feet. The pine forests form a pure growth of an open character, but here and there are clumps of scrub oak, composed

1) Greene, E. L.: See Bibl. p. 83. I: 261; Vasey, G. and Rose, J. N.: San Benito Isl. Pl.: See p. 86.

on Alamos Mountain of *Quercus grisea* (= *Q. undulata*), *Q. californica* (= *Q. Kelloggii*) and on the oaks *Tillandsia recurvata*.

Low ranges, or the bluffs of dry ravines, or of watered valleys are covered with Quercus grisea, (Q. Emoryi having been left behind) associated with Pinus chihuahuana and more rarely P. microphylla [1]. The most abundant tree of these forests next to Quercus grisea is Pinus arizonica, ranging through 3,000 feet of elevation from the valleys and canyons of the base to the highest summits, while Pinus strobiformis (= P. ayacahuite) is scatteringly distributed along canyons on high cool slopes. Pinus cembroides grows on the warmest and most arid slopes and on ledges with meager soil. Juniperus pachyphloea has an altitudinal range of 5,000 feet, attaining its full development in rich and watered canyons. On the driest crests of ridges near the summits, Juniperus tetragona occurs, while in better soil at still higher altitudes is Juniperus occidentalis var. conjugens, and Pseudotsuga Douglasii is found in high canyons associated with Pinus arizonica and Abies concolor.

Above these trees on the cool talus of cliffs grows Populus tremuloides. The sides and bottoms of wet canyons are characterized by Quercus reticulata with Q. hypoleuca, Q. fulva. Sparsely scattered over these mountains is Arbutus xalapensis, while Arbutus petiolaris is confined entirely to the northern verge of ridges. Among the oaks the underbrush consists of Ceanothus Fendleri, C. azureus, C. parvifolius (on rocky hills), Arctostaphylos pungens with Pinus cembroides, Spiraea discolor var. dumosa about the ledges of the summits. At 8000 feet in the Tarahumara country pines cover the higher elevations in an uninterrupted forest and oaks the lower slopes of the mountains. Pinus oocarpa grows on the summit of Alamos Mountain.

*Park Formation.* Many of the valleys are park-like with a grassy sward with agaves interspersed and groups of fresh green trees pointing to places where the ground is wet or moist [2]) during the dry season from January to June. Here are found species of *Helianthus* (10—12 feet high), *Salvia*, *Sambucus* and *Bambusa*, which forms a light green undergrowth, and along the smaller streams occur ash trees, alders, madroña and *Euonymus* with *Mimulus*, *Aquilegia*, *Thalictrum* and an *Amaryllis* with carmine red flowers, visited by humming birds. Species of *Viola*, *Vicia* and *Lupinus* grow in the pine forests at 7,400 feet.

The flora of the canyons and mountain water courses is composed of *Acalypha subviscida*, *Gouania domingensis*, *Vitis arizonica*, *Rhus Palmeri*, *Leucaena lanceolata*, *Sedum alamosanum* and species of *Sicyosperma*, *Stevia*, *Brickellia*, *Baccharis*, *Melampodium*, *Zexmenia*, *Tagetes*, *Salvia*, *Muhlenbergia*.

## 2. Forest Formations in higher elevation.

The Chiricahua, the Huachuca, the Santa Rita, the Rincon and the Santa Catalina Mountains form the northern extension of the Mexican Sierra Nevada Mountains into Arizona, and lying south of the great Colorado Plateau the presence of many Mexican trees unites these mountains, phytogeographically speaking, with the flora of Mexico proper. The greatest elevations are from 9,000 to 10,000 feet and good forest is not common below 7,000 feet.

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1) PRINGLE, C. G.: Garden and Forest I: 238, 429, 441.

2) LUMHOLZ, CARL: Unknown Mexico I: 408.

Limestone cliffs in the Chiricahua Mountains are characterized by fine specimens of Morus eltidifolia, Quercus undulata, Bumelia spinosa, while along the wash from White River Canyon rew Chilopsis saligna, Salix nigra var. venulosa, S. longifolia var., Platanus Wrightii, Fraxinus elutina, Juglans rupestris. At the entrance to the canyon are Juniperus pachyphloea, J. mono- perma, Quercus Emoryi and Alnus oblongifolia. The mountain slopes are characterized by large reas of scrub oak composed of Quercus undulata, Q. hypoleuca, Q. chrysolepis var. vaccinifolia nd on the upper slopes among the pine Q. Gambelii and Q. reticulata. Yucca macrocarpa ccurs throughout the south and central portions of the Chiricahua Mountains, while Yucca bac- ata grows on the east slopes and Y. elata on the flanking mesas. At higher elevations are und Pinus cembroides, P. chihuahuana and P. ponderosa. Pinus cembroides, covers with a ther dense forest, the highest slopes of these mountains, Abies concolor, Pseudotsuga Douglasii nd Cupressus arizonica are not infrequent in canyons above 5,000 feet while Pinus reflexa grows n the summits. In some of the canyons are found Acer grandidentatum, Negundo aceroides and runus serotina[1]. Cercocarpus parvifolius var. paucidentatus and Rhamnus Purshiana var. tomen- lla are frequent throughout the entire range, while large areas in the valleys are covered with stunted growth of Prosopis juliflora and Koeberlinia spinosa.

Over fifty-five species of trees are reported from the Chiricahua Mountains s follows:

ondalia obovata Hook.
oeberlinia spinosa Zucc.
hamnus Purshiana DC.
» Purshiana tomentella Benth.
cer grandidentatum Nutt. var. (=Acer barbatum var. grandidentatum Sarg.).
egundo aceroides Moench (= Acer negundo L.).
apindus marginatus Willd.
cacia Berlandieri.
» Greggii A. Gray.
osopis juliflora DC.
rkinsonia Torreyana Wats.
» microphylla Torr.
ysenhardtia orthocarpa Wats.
unus serotina Ehrh.
auquelinia californica Sarg.
ercocarpus parvifolius Nutt. var. paucidentatus Watson.
ereus (Carnegiea) giganteus Engelm.
puntia arborescens Engelm.
» fulgida Engelm.
mbucus mexicana DC.
rbutus arizonica Sarg.
Bumelia spinosa Wats. (=B. lanuginosa Michx. var. rigida A. Gray).
Fraxinus velutina Torr. (= F. pistaciaefolia Torr.).
Chilopsis saligna Don (= C. linearis [Cav.).
Celtis mississippiensis Bosc. var. reticulata Sarg.
Morus celtidifolia H. B. K.
Platanus Wrightii Wats.
Juglans rupestris Engelm.
Quercus Gambelii Nutt.
» undulata Torr.
» oblongifolia Torr.
» grisea Liebm.
» reticulata H. B. K.
» chrysolepis Liebm. var. vaccinifolia Engelm.
» Emoryi Torr.
» hypoleuca Engelm.
Alnus oblongifolia Torr. (= A. acuminata H.B.K.).
Salix nigra Marsh.
» longifolia Muhl. var.
Populus tremuloides Michx.
» Fremontii Wats.

1) Toumey, J. W.: Notes on the tree Flora of the Chiricahua Mountains. Garden and rest VIII: 12, 22; Blumer, J. C.: On the plant Geography of the Chiricahua Mts., Ariz. ience new ser. XXX: 720—724.

Cupressus Arizonica Greene.
Juniperus pachyphloea Torr.
» occidentalis Hook var. monosperma Engelm.
» virginiana L.
Pinus reflexa Engelm.
» cembroides Zucc.
» arizonica Engelm.
» ponderosa Laws.
Pinus latifolia Sarg. (= P. Mayriana
» chihuahuana Engelm. (Sudw.).
» strobiformis Engelm.
Pseudotsuga Douglasii Carr (= P. taxifolia Poir.).
Abies concolor Lindl. & Gord.
Yucca elata Engelm. (= Y. radiosa Engelm.).
» macrocarpa Cav.

In the Santa Rita Mts. occur such herbs as Phacelia crenulata, Castilleia integra, Rumex hymenosepalus with such woody plants as Cereus phoeniceus, Fendlera rupicola while the descending slopes are covered with Astragalus mollissimus, A. missouriensis, A. humistratus, A. cobrensis, A. Shortianus and A. Nuttallianus. The canyons of the Huachuca Mountains have among other plants, the following: Ceanothus integerrimus, Vitis arizonica, Robinia neomexicana, Stevia Plummerae, S. serrata, Erigeron divergens (under bushes), Cacalia decomposita, Euphorbia montana, Guilleminea densa (= G. illecebroides), Lilium Parryi, while on the canyon sides grow Cereus caespitosus, Opuntia arborescens, Baccharis pteronioides, etc.[1]).

## 3. Chihuahuan Desert Region.

This phytogeographic region is coincident with the central Mexican tableland which stretches at a nearly uniform elevation of 7,500 feet for a distance of about a thousand miles, north and south. But the uniformity of this plain formed by the progressive and long-continued accumulation of detrital material is broken by barrancas, or enormous ravines, sinking hundreds, perhaps even a thousand feet into the ground and measuring several miles across. The climatic conditions, lack of rainfall, etc. render this plain an arid waste, or desert, where xerophytic, succulent plants (see *Cactaceae* Fig. 30) form the marked feature of the vegetation. Three types of succulent plants form the bulk of the xerophytic vegetation of the Chihuahuan desert region, viz., the cactus type, the yucca type and the agave type.

The country bordering the Rio Grande in Chihuahua and Texas is nearly destitute of trees, except in certain localities, as on the bottom lands of the Rio Grande and Rio Concho. The lowlands are thickly set with *Prosopis glandulosa* and along the arroyos grow *Populus monilifera*, or *P. angustifolia*, *Celtis occidentalis*, *Juglans rupestris*, *Ungnadia speciosa*, *Guaiacum Coulteri*, *Larrea Mexicana* and *Fouquiera splendens*[2]).

*Chaparral Formations.* These are best developed in trans-Pecos, Texas, and the same type is found in the northern part of the Mexican plateau. Compared with the Rio Grande chaparral (later to be discussed), the Mimoseae and Caesalpinieae form according to BRAY less than ten per cent of the species, while *Prosopis juliflora* becomes a shrubby plant and a greater abundance of the *Ephedra*, *Croton*, *Eurotia* and *Larrea* types is also noteworthy.

1) ROSE, J. N.; List of Plants: see Bibliography p. 78.
2) NEWBERRY, J. S: See Bibliography p. 77.

This semiarid region is largely mesquite (*Prosopis*) plains, varying from open grassy land with scattered mesquite to a scrub forest of this tree, in places densely filled with other thorny bushes and cactuses, as along the southern stream valleys and over much of the plains of the lower Rio Grande. Scattered oaks, according to BAILEY [1], and other scrub trees distinguish the more elevated, rougher parts of the region and narrow strips of good timber are found along some of the streams. The bulk of this chaparral consists of *Zizyphus obtusifolius*, *Condalia obovata*, *Koeberlinia spinosa*, *Opuntia Engelmannii*, *O. leptocaulis*, *Parkinsonia aculeata*, *Acacia farnesiana*, with *Tillandsia recurvata* etc.

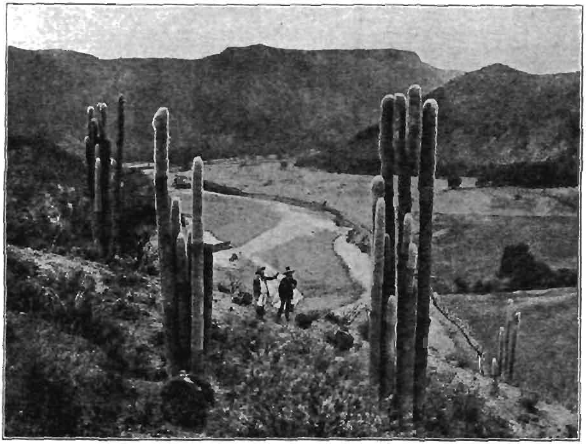

Fig. 30. LANDSCAPE WITH CACTACEAE IN MEXICAN STATE HIDALGO.
Columnar form of Cephalocereus senilis (Haw.) K. Sch. — Ball form of Echinocactus ingens Zucc.
(Engler-Prantl, Nat.-Fam. III 6a No. 2.)

Larrea Mexicana in a formation of a single species is especially characteristic of high gravelly mesas and of the bolson deserts extending even to highly charged alkaline soils; it is a shrub and is disposed in such regular open growth as to appear like plantations.

Succulents, Yucca and Agave. Approaching the crest of broad undulations or any relief feature visible above the general surface of the plains in trans-Pecos Texas, a unique yucca vegetation is seen to occupy such situations. Again on the rim of the enclosed bolson basins, plants of the succulent association are present and finally on many of the gentler slopes of the mountains the succulents are present as the chief vegetation feature. — Yucca macrocarpa is very abundant in the great bend country, covering the long arid slopes with an open association of yucca trees "with caudex ten to twenty feet high and one to two feet in diameter". —

1) BAILEY, V.: See Bibl. p. 75.

Agave heteracantha forms a very characteristic association of very rough stony slopes in which this Agave grows associated with Dasylirion texanum. — The Cactus Association includes several species of Mamillaria, Cereus (C. stramineus), Echinocactus (E. Ancistrocactus longihamatus) and Anhalonium. Such an association indicates extreme exposure to intense light, burning midday and chilling midnight temperatures, and moistureless air and soil. Mixed in with the above associations is Fouquiera with slender, thorny wand-like stems growing in the most arid spots of the desert.

Alkali Playa- and Desert Dune Formation. Typically the Alkali playas occur on the Pecos flats and in the Salt Lake basin (the Howard basin). The prevalent grass according to HAVARD[1]) on the Pecos flats is Sporobolus airoides while on alkaline soils occur Suaeda suffrutescens, S. depressa and Spirostachys occidentalis. The low sand hillocks in the Howard basin are covered with Spirostachys, Larrea mexicana and Frankenia Jamesii. — South of El Paso, according to COVILLE and MAC DOUGAL[2]), is a long stretch of sand dunes about forty feet high. The vegetation consists of Poliomintha incana, Yucca radiosa (= Y. elata), Sporobolus cryptandrus and species of Artemisia, Chrysothamnus and Andropogon.

*River Valleys and Canyons.* At Presidio del Norte, 953 miles from the mouth of the Rio Grande and at an altitude of 2,780 feet (847 m), the sparse tree vegetation is confined to alluvial bottoms and ravines. The trees are *Populus Fremontii*, *Celtis occidentalis*, *Prosopis juliflora*, *P. pubescens*, *Salix longifolia* and *S. nigra*. Shrubs and bushes are common, but in scattered thickets nowhere, according to HAVARD, forming dense thickets.

In Chihuahua associated with Populus Fremontii var. Wislizeni along water courses from the mountains down into the arid plain are Salix irrorata, S. taxifolia, Fraxinus velutina, Sambucus mexicana, Juglans rupestris and Celtis occidentalis var. reticulata[3]). On a few bottoms Prosopis juliflora occurs associated with Celtis pallida (in dense clumps), Mimosa biuncifera, Acacia Greggii, Microrhamnus ericoides, Condalia spathulata and Koeberlinia spinosa. The herbaceous plants of the bottom lands are species of Hoffmanseggia, Sphaeralcea, Lepidium, Tetraclea, Philibertia, Argemone, Oenothera, Martynia, Tribulus and Collomia longiflora with the coarse maton grass, Sporobolus Wrightii. At Eagle Pass the vegetation begins to change into the chaparral formation of the lower Rio Grande. The canyons of the Rio Grande below Presidio are characterized by the presence of Acacia Schottii, Boerhaavia bracteosa, Bouchea linifolia, Mimosa fragrans, Acacia filicina, Salvia Henryi and Nama undulatum. In general throughout these canyons, vegetation is scant, sometimes entirely absent. — Those plants preponderating on mesas and hills are (Mesa Formation): Acacia Greggii, A. constricta, Mimosa borealis, M. biuncifera, Dalea formosa, Condalia obovata and C. spathulata, Zizyphus obtusifolius, Koeberlinia spinosa, Larrea, Jatropha, Celtis pallida, Lycium carolinianum, L. Berlandieri, L. puberulum, Agave heteracantha, Dasylirion texanum, Yucca angustifolia, Cereus (Peniocereus) Greggii and stramineus, Anhalonium (Ariocarpus) fissuratum, A. (Lophophora) Williamsii and Ephedra antisyphilitica[4]).

At Eagle Pass 495 miles above the mouth of the Rio Grande and elevated 1,460 feet (= 445 m) above sea-level, Dasylirion texanum has disappeared and Yucca baccata becomes dwarfed. Acacia Greggii and A. constricta of the gravelly mesas at Presidio are here replaced by Acacia amentacea, A. Berlandieri, A. Coulteri, and A. Wrightii. Prosopis pubescens has vanished, but P. juliflora is common and attacked by a parasite, Phoradendron flavescens. Here begin Parkinsonia aculeata and Acacia farnesiana, transitional to the chaparral below, together with Lippia lycioides (= L. ligustrina), L. graveolens, Salvia ballotaeflora and Porliera angustifolia.

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1) HAVARD, V.: See Bibliography p. 68.
2) COVILLE, F. V. and MAC DOUGAL, D. T.: See Bibliography p. 75.
3) PRINGLE, C. G.: Garden and Forest I: 105—106 (see Bibl. p. 85).
4) HAVARD, V.: L. c. in Proceedings U. S. Nat. Mus. VIII. 1885: 470—474.

In the absence of a detailed description[1]) of the plants found in these formations, it has been found expedient to mention the plants which grow in this great territory by grouping them into divisions, such as, leguminous plants, cactaceous and compositous plants. All of the plants of these orders, as well as those of the Gramineae and Liliaceae, furnish plants which have adapted themselves to the dry soil and other desert conditions. Many of them, especially the yuccas, agaves and cacti have assumed a morphologic character which is an expression of their desert habitats.

The trees of the desert mountain ranges and dry canyons of Chihuahua are limited to a few species: Pinus chihuahuana, Quercus Emoryi, Q. grisea (= Q. undulata), Q. oblongifolia, Fraxinus cuspidata and Juniperus occidentalis var. conjugens. These species grow on thedry mountain ranges which rise from the plains to an elevation of 6,000 to 8,000 feet.

The Cactaceae[2]) are represented by following important species:

Melocactus ferox.
Mamillaria anguinea.
» bicolor.
» centricirrha.
» conoidea.
» conopsea.
» crebrispina.
» erecta.
» formosa.
» hexacantha.
» hystrix.
» implexicoma.
» longimamma.
» raphidacantha.
» Scheidweileriana.

Mamillaria scolymoides.
» sphaerotricha.
Echinocactus coptogonus.
» hexaëdrophorus.
» helophorus.
» hexaëdrus.
» hystrichacanthus.
» latispinus (= E. cornigerus).
» longihamatus.
» macrodiscus.
» myriostigma.
» pectiniferus.
» quadrinatus.

Echinocactus rhodophthalmus.
» tricuspidatus (= E. phyllacanthus).
» uncinatus.
» ingens.
Opuntia rufida.
» Schottii.
» tunicata.
» vulgaris.
» leptocaulis.
Cereus (Echinocereus) pectinatus.
» geometrizans (s. Fig. 31).

Among the leguminous plants characteristic of the region are Indigofera Lindheimeriana, Peteria scoparia, Astragalus diphacus, A. coriaceus, A. leptocarpus, A. parvus, Hosackia puberula, Lupinus canus and Sesbania longifolia, Crotalaria sagittalis, Glycyrrhiza lepidota, Prosopis pubescens and many other species of the genera Petalostemon, Dalea, Tephrosia (= Cracca), Astragalus, Galactia, Rhynchosia, Hoffmanseggia, Parkinsonia, Cassia, Desmanthus, Mimosa, Acacia, Calliandra and Pithecolobium.

The species of the genus Yucca, which reach the size of small trees and are of American desert origin (see ante page 298), find their most luxuriant development and center of distribution in the Chihuahuan desert region. The following yuccas are limited to this region: Y. Treculeana, Y. australis, Y. valida, Y. rigida, Y. rostrata, Y. radiosa, Y. macrocarpa, Hesperaloë funifera[3]). Some of the species of Agave of this desert region are Agave applanata, A. asperrima, A. Brauniana, A. (Manfreda) guttata, A. Humboldtiana, A. Peacockii, A. Smithiana, A. Wislizeni and A. zylonacantha[4]).

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1) Kirkwood, J. E.: Desert Scenes in Zacatecas. Pop. Sci. Month. LXXV: 435—451.

2) The names in Hemsley's Biologia and Schumann's Monograph have been retained although as previously stated the entire family has been reorganized.

3) Ramirez, José: La Vegetacion de Mexico. 1899 Page 115; Trelease, The Yucceae. Thirteenth Annual Report (1902) Missouri Botanical Garden, pp. 27—133.

4) Segura, José C. y Cordero, Manuel D.: Resena sobre el Cultivo de algunas Plantas Industriales. Mexico 1884 El. Maguey pp. 207—277.

The order Compositae is represented in the Chihuahuan desert by numerous endemic species among which may be counted the following:

Vernonia liatroides.
Stevia Berlandieri.
» elatior.
» ranunculoides.
» stenophylla.
» unicristata.
Fleischmannia Schaffneri.
Eupatorium amplifolium.
» azureum.
» scorodonioides.
» Schaffneri.
Barroetea setosa.
Brickellia Coulteri.
» diffusa.
» lanata.
» Palmeri.
» squamulosa.
Gymnosperma scoparium (= G. corymbosum).
Xanthocephalum Benthamianum.
Xanthocephalum sericocarpum.
Gutierrezia Berlandieri.
Bigelovia oppositifolia.
Solidago scabrida.
Aster potosinus.
Conyza microcephala.
Baccharis potosina.
Pluchea auriculata.
» camphorata.
Gnaphalium gracile.
» oxyphyllum.
Trigonospermum melampodioides.
Melampodium longicorne.
Parthenium argentatum.
Aioltheca parthenioides.
Ambrosia confertiflora (=Franseria tenuifolia).
Tragoceros microglossum.
Philactis longipes.
Zinnia juniperifolia.
» linearis.
Sanvitalia acinifolia (= S. procumbens).
Zaluzania mollissima.
Gymnolomia multiflora.
Zexmenia gnaphalioides.
Viguiera canescens.
Helianthus amplexicaulis.
Perymenium parvifolium.
Encelia lagascaeformis.
Helianthella mexicana.
Verbesina hypoleuca.
Spilanthes bicolor.
Dahlia gracilis.
Cosmos diversifolius.
Bidens angustissima.
» heterophylla.
Calea albida.
» elegans.
Tridax candidissima.
Eutetras Palmeri.
Microspermum nummulariaefolium.
Tagetes Parryi.
Cotula pygmaea.
Perezia oxylepis.
» rigida.
» turbinata.
Trixis conferta.
Senecio praecox.

At the southern extremity of the Chihuahuan desert region, as shown in the contracted portion in the map, for example in the valleys at Tehuacan, the desert vegetation reigns supreme. Here the soil is rocky, mostly limestone. According to MACDOUGAL[1]) the main valley at Tehuacan was north on the eastern side of the main continental ridge and this and the neighboring valleys and slopes are a part of one of the most striking deserts in the world, the xerophilous vegetation offers remarkable features of adaptation and distribution. The abundance of the Cactaceae rivals or surposses even that of the southern part of Arizona and of Sonora and a half dozen of the species being massive forms, the landscape is highly characterized by them. *Cereus* (*Lemaireocereus*) *Weberi*, the "garambullo" *Cereus* (*Myrtillocactus*) *geometrizans* (see Fig. 31) *Cephalocereus* (see Fig. 30) *macrocephalus*, *Pilocereus fulviceps*, *chrysacanthus* and *Tetetzo*, *Escontria Chiotilla*, *Agave marmorata*, together with others which reach a height and attain a bulk as great or greater, than *Cereus giganteus*. Of the half dozen species of *Echinocactus* (*E. grandis*, *flavescens*, *robustus*), one forms huge mounds of small individuals as much as three yards across, while *E. grandis* reaches the size of the saguaro, *Cereus* (*Carnegiea*) *giganteus*. In addition to the cacti, euphorbias, agaves and related forms, the tree morning glory (*Ipomoea* spec.) has a soft, thick trunk for storage purposes.

1) Journal New York Botanical Garden VIII: 4.

Three species of *Beaucarnea* (among them *B. oedipus*) known locally as "sotol" have the bases of their stems swollen to the thickness of seven or eight, feet with a height not more than two or three limes this measurement.

On the hills, a gray, dwarf vegetation is encountered, consisting of *Echinocactus ingens* associated with *Yucca aloifolia*, *Dasylirion acrotrichum* (?), composite herbs and discontinuous grassy clumps. In other associations in the vicinity occur, according to KARSTEN [1]), *Agave horrida*, *Echinocactus ingens* (see Fig. 30 at p. 644) and on a leafless shrub grows *Tillandsia recurvata*. Another association consists of *Cereus Pecten aboriginum* (see Fig. 9, p. 297),

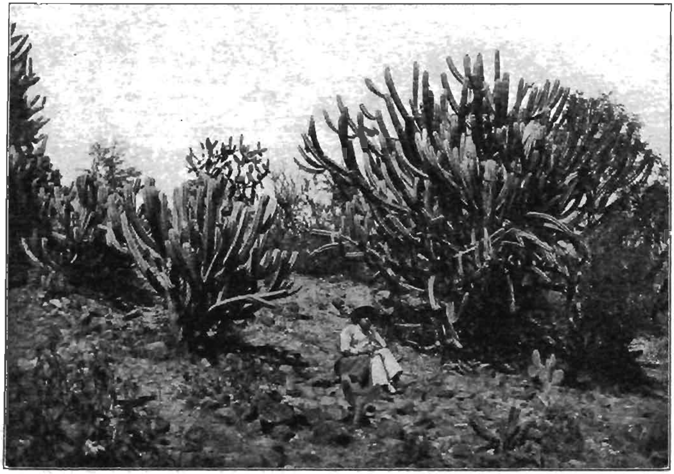

Fig. 31. *Cereus (Myrtillocactus) geometrizans* Mart. (Garambullo). Chihuahuan Desert Region, Mexico.

*Prosopis juliflora* and *Cereus (Pachycereus) marginatus*, while on the limestone plateau at Hacienda Carnero, Tehuacan, grow together in association *Echinocactus robustus*, *Mamillaria mutabilis* and *Tradescantia navicularis*. Elsewhere, the gray vegetal covering of the soil is found to consist of species of *Agave*, *Dasylirion*, earth inhabiting bromeliads, species of *Sedum* and *Echeveria*, thorn-bearing shrubs, such as, *Mimosa*, *Cassia*, many compositous plants and *Ephedra*. The grassy covering is thin and sparse, beset with species of cactaceous plants.

1) SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage. 1898. 678—679; KARSTEN, G. and STAHL, E.: Mexikanische Kakteen-, Agave- und Bromeliaceen-Vegetation. Vegetationsbilder Heft 8.

## 4. Eastern Sierra Madre Region.

This forms a narrow strip running along the eastern edge of the Mexican tableland extending north of Monterey to the Rio Grande, before reaching which the chain of mountains becomes less distinct and at last identic with the mountains of the tableland. From Presidio on the Rio Grande, the botanist sees a lofty mountain (Sierra Rica, 9,000 feet) in the southeast in the state of Chihuahua. Its summit is covered with *Pinus cembroides* and its slopes with *Quercus undulata* (= *Q. grisea*) and *Arbutus xalapensis*. Three miles below Eagle Pass, according to HAVARD (loc. cit.), the banks of the Rio Escondido, a clear, swift stream, on the Mexican side is shaded with *Carya olivaeformis* (= *Hicoria pecan*), *Morus celtidifolia*, *Celtis occidentalis* over which climb *Vitis candicans*. On the bluffs above are groves of *Quercus virginiana* (= *Q. virens*) extending along the hill tops into the interior of Coahuila.

For some two hundred miles of its extent the Sierra Madre Oriental is included within the Mexican state of Nuevo Leon and a sketch of the flora of the mountains in this territory will to great extent, in lack of more complete information about the vegetation of the whole chain, express the general phytogeographic character of the region. The low eastern Sierra Madre Mountains are steep, rough, seamed by numerous canyons and afford a good illustration of the arid conditions which prevail east of the Mexican tableland, where the limestone of the mountains is contorted and twisted, scarcely half concealed beneath a thin covering of soil, which is barely sufficient to support a low, dingy, green growth of agaves, cactuses and desert shrubs.

On the western side near Monterey are found Pinus cembroides, associated with Pinus latisquama (on the dry calcareous bluffs of gulches), Quercus undulata, and Yucca Treculeana (in thin forests near the base[1]). On the higher summits is Pinus teocote, while on the shaded and cooler higher slopes, especially in the ravines with northern aspect, are groves or belts of Pseudotsuga Douglasii, associated in the ravines toward the base with Cupressus guadalupensis, while Juniperus flaccida and J. tetragona var. oligosperma occur in canyons near the base. The sunnier, drier slopes are covered with a dense growth of shrubs consisting of Quercus reticulata, Q. undulata and in rich canyons Q. reticulata becomes a tree and grows associated with Q. Emoryi and Q. virginiana.

The foothills are mainly, according to PRINGLE, ledges of limestone with the usual growth of cactuses, agaves and a shrubby vegetation consisting of Lindleya mespiloides, Cercocarpus parvifolius, Cowania plicata, Fraxinus Greggii, Arbutus xalapensis, Arctostaphylos pungens, Microrhamnus ericoides, Rhus microphylla, Ceanothus Greggii and Ephedra aspera.

The eastern, rain-visited slopes of these mountains south of Monterey mark the northern limit of Pinus Montezumae. Belts of Carya myristicaeformis are found largely excluding other species. The wet canyons of lower slopes are occupied by a dense growth of Juglans rupestris, Quercus polymorpha (attaining a size of two feet by sixty), Quercus virginiana, with maximum diameter three to five feet, Platanus mexicana, Fraxinus viridis, Morus urticaefolia, Tilia mexicana, Chilopsis saligna, Ulmus crassifolia (on river bottoms), Prunus americana var., Prunus capollin, Planera aquatica, Bumelia lanuginosa var. rigida, Cercis reniformis, Leucaena pulverulenta, Cornus florida (one foot by twenty five) and Staphylea mexicana. Outside of the canyons, several of the above trees mingle with Quercus Grahamii (a small tree most abundant

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1) PRINGLE, C. G.: Notes lign. Veget. Sierra Madre, see Bibliogr. p. 85.

from the lower to the higher slopes), Q. oblongifolia and Arbutus xalapensis. The upland palmetto Brahea dulcis inhabits the precipitous ledges of limestone. About the base of the mountains, especially on limestone ledges associated with Fraxinus Greggii, Helietta parvifolia, *Diospyros texana, occur Amyris madrensis and Sargentia Greggii. Common in rock valleys among* the foothills are Acacia farnesiana, A. flexicaulis, Ehretia elliptica, Pithecolobium brevifolium and occasionally Sapindus acuminatus.

In the Guadalcazar Mountains the principal arborescent species are Quercus undulata, Q. polymorpha, Juglans mexicana and Sargentia Greggii. In meager soil, partially covering extensive ledges of lime-rock, grow Neopringlea integrifolia, while rooting in the fissures is Dahlia dissecta and on the ledges, such ferns as Pellaea pulchella, Notholaena sinuata, N. Aschenborniana and Cheilanthes leucopoda[1]).

## 5. United Cordilleran Region.

This region includes the confused mass of mountain ranges formed by the union of the western and eastern Sierra Madre chains. The topography of this region is rendered more complicated by the fact that a system of volcanoes is disposed transversely to the trend of the Sierra Madre Occidental and Sierra Madre Oriental between the Gulf of Mexico and the Pacific Ocean. High above this central Cordilleran system tower the snow-capped peaks of several volcanoes (see ante p. 113), of which Orizaba (Citlaltepetl) stands isolated from the others and rises from the tierra caliente to an elevation of 18,250 feet. Several large valleys, such as Mexico and Toluca, are situated at a general elevation of about 7,500 feet and are almost completely hemmed in by mountain masses, which form elevated rims to these valleys filled with lakes. The flora of the valleys and surrounding chains will be presented first, and then, as far as the data will permit, a sketch of the vegetation of the high volcanoes will be given.

### 1. Valley, Lakes, Dry Ridges.

The soil of the valley of Mexico being a fine, light loam, it has been under a high state of cultivation for many centuries. Little of the original flora is found in the cultivated areas, but the botanist notices some interesting species near the town of Tlalpam[2]). The valley of Toluca is the most elevated valley of much extent in Mexico, being 8,500 feet above the level of the sea, one thousand feet higher than the valley of Mexico. In its upper, or southern portion lie Lake Lerma and its marshes fed by mountain brooks, which tumble down from the Sierra de las Cruces. During the summer, parts of this valley are solid with corn, while during the earlier part of the year, wheat occupies the same ground.

Lake Formation. According to my observations, the following aquatic plants are found in the lakes of the valley of Mexico. In Lake Xochimilcho, I collected Nymphaea mexicana, N. tussilagifolia, Eichhornia azurea, Marsilia quadrifolia, while on the wet chinampas, or floating marshy

islands were noticed Sagittaria sagittifolia var. mexicana, Cyperus unioloides, Eriocaulon Benthamii, Polygonum amphibium, Lobelia fulgens, Solidago paniculata, Cnicus linearifolius, Bidens chrysanthemoides and in the ditches Ranunculus cymbalaria, R. orthorhynchus and a species of Arundo, etc. In Lake Lerma in the valley of Toluca grows Nymphaea gracilis.

*Dry Ridge- and Pedregal-Formation.* The dry hills in the valley of Mexico support a scant vegetation. On the Cerro de Guadalupe, connected with the western mountain chain by a low ridge, Cuesta de Barrientos, I noted *Milla biflora* (on exposed rocks), *Talinum aurantiacum* (on rock faces), *T. patens* [1]), *Oxalis decaphylla*, *Mamillaria strobiliformis*, *Tecoma mollis*.

The pedregal, or lava bed was formed by streams of lava that flowed from Serrania de Ajusco down through a distance of twenty-five miles over nearly all the mountain side and over the southern edge of the Valley of Mexico. It consists of sharp ridges alternating with deep crevasses. Doubtless, it was once covered with a scanty forest growth, because on the mountain side at 8—10,000 feet, I noted groves of *Pinus leiophylla* associated with *Quercus reticulata*, *Q. undulata* and beneath these trees three species of *Dahlia* (*D. Merckii*, *D. coccinea*, *D. variabilis*) with masses upon masses of conspicuous bloom, *Ceanothus azureus*, *Lupinus silvaticus*, *Physalis pubescens* and parasitic upon the oak roots *Conopholis mexicana*, while *Agave megalacantha* is dotted here and there among the other plants. In the pockets in the lava rock occurs between many herbs the curious, composite, woody plant, *Senecio praecox* with water storing stems [2]). *Selaginella lepidophylla* (a resurrection plant) is abundant on the faces of the lava ridges, associated with *Notholaena ferruginea*, *Cheilanthes myriophylla*, *Pellaea gracilis*. Several grasses also are abundant: *Bouteloua prostrata*, *Microchloa setacea* and a sedge, *Cyperus sesleroides*. — The lava beds (pedregal) at a still higher elevation, 11,000 feet on the Sierra del Ajusco, are characterized by *Juniperus tetragona*, *Pinus Montezumae*, associated with smaller plants, growing out of the soil-filled pockets in the lava.

## 2. Forests and Mountain Meadows.

*Coniferous Forest Formation.* The pine belt is typically developed on the Sierra del Ajusco between 8,000 and 11,000 feet. *Pinus leiophylla* which grows in pure forests at about 9,000 feet is replaced higher up by *Pinus Montezumae*. On the slopes of the mountains above the valley of Toluca, this pine and another unidentified pine form almost pure forests. *Alnus acuminata* forms the fringe to the forest and the cool wet ravines are characterized by the presence of *Abies religiosa*. This sub-alpine mountain tree forms the Abies religiosa Belt with at times *Pinus Montezumae* intermixed. The undergrowth consists of *Alnus acuminatus*, *Buddleia Humboldtiana*, *Arbutus*,

1) HARSHBERGER, J. W.: Ecolog. Study genus Talinum: see Bibliogr. p. 83.

2) HARSHBERGER, JOHN, W.: Water Storage in Senecio praecox: see Bibliogr. p. 83; MAC DOUGAL, D. T.: The Pedregal. The Plant World X: 285.

*Fuchsia microphylla*, *F. thymifolia*, *Vaccinium*, *Ribes*, *Lonicera*. In shady mossy places are found three orchids: *Microstylis streptopetala*, *M. platyglossa*, *M. tenuis*, and according to my observations at Salazar, *Weldenia candida*, *Thalictrum tomentellum*, *Pentstemon gentianoides* and *Pirola secunda*[1].

*Meadow Formation*. This was examined by me at two places: La Cima and Salazar. The plain of Salazar is spread out in the broad lap of the mountain knobs and is flanked by dense forests of *Abies religiosa*. Here on the grassy battle field, where in *1810*, Hidalgo defeated the Spaniards, grow many sub-alpine species.

In sunny situations, according to E. STAHL[2], are found between the grass clumps Pedicularis orizabae, Arenaria decussata, Arabis laevigata, Oxalis violacea, Geranium elongatum, Astragalus Seatonii, Eryngium bromeliaefolium. On August 13th, 1896 in company with Mr. C. G. PRINGLE and a Mexican assistant, TRANQUELINO DURAN, I collected the following plants in the grassy meadows at Salazar: Brachypodium mexicanum, Sisyrinchium Schaffneri, Urtica Breweri, Claytonia perfoliata, Arenaria alsinoides, A. decussata, Cerastium viscosum, Ranunculus stoloniferus, R. dichotomus, Potentilla candicans (forming a large part of the turf), Fragaria mexicana, Trifolium involucratum, Astragalus strigulosus var. gracilis, Erodium cicutarium, Oxalis violacea, O. corniculata var. repens, Linum mexicanum, Euphorbia campestris, Viola Grahami, V. flagelliformis, Epilobium Bonplandianum, Angelica Pringlei, Eryngium ranunculoides, E. dilatatum, Salvia fulgens, S. nana, Stachys coccinea, S. repens, Prunella vulgaris, Physalis lobata, Solanum tuberosum (probably wild), Sibthorpia pichinchensis, Castilleja tenuiflora, C. Schaffneri, Mimulus luteus, Plantago patagonica, P. hirtella, Houstonia Palmeri, Lobelia nana, L. fulgens, Gnaphalium purpureum, Eupatorium popocatepetlense, E. pycnocephalum.

## 3. Plant Formations of the Volcanic Peaks.

**Orizaba.** Mount Orizaba has its base buried in the luxuriant forests of the eastern tierra caliente presenting an unbroken series of mountain belts up to the line of perpetual snow, 15,000 feet above sea-level. There is perhaps no other mountain which so thoroughly presents the sequence of floristic belts as the peak of Orizaba. Between 4,000 and 6,000 feet, *Quercus reticulata* and *Q. Orizabae* form the forest, but above 8,000 feet, they are comparatively rare, and up to 10,000 feet are scattered through the pine forests. Associated with the oaks are *Tilia mexicana*, *Alnus jorullensis*, *A. castaneaefolia*, *Fuchsia microphylla*, *Govenia speciosa*, *Neottia* (*Spiranthes*) *aurantiaca*, *Ferraria* (*Tigridia*) *pavonia*, *Dracocephalum mexicanum*, *Chimaphila maculata* and species of the genera *Gaultheria*, *Andromeda*, and *Arbutus spinulosus*, the last with a tree known as madroño[3].

Coniferous Forest Formation. The summit of Mount Orizaba rises above a forest of pines which begins with Pinus leiophylla at 6,600 feet and at 9,000 feet consists of Pinus montezumae var. macrophylla, P. teocote and P. pseudostrobus. The lower limit is perhaps regulated

1) HARSHBERGER, JOHN, W.: Botan. Excursion to Mexico: see Bibl. p. 83; also Botan. Observ. Mex. Fl. loc. cit.

2) STAHL, E.: Mexikanische Nadelhölzer in KARSTEN, G. und SCHENCK, H., Vegetationsbilder. Zweite Reihe, Heft 3 und 4. Tafel 17 und 18.

3) LIEBMANN, FR.: Vulkan Orizaba. Botanische Zeitung 1844: see Bibliography p. 84; GADOW, HANS: Through southern Mexico; 1908: 41—72.

by the fields of ash and scoria which prohibit the growth of pine species, and not by the absolute amount of temperature which is peculiar to each species of tree. The plants of these pine woods are Ranunculus geoides (11,000 feet), Cerastium orithales (13,000 feet), C. vulcanicum (11,000 feet), Sambucus mexicana (10,000 feet), Arracacia nudicaulis (12,000 feet), Tillandsia punctulata (10,000 feet)[1]), compare the observations of LIEBMANN, made in 1844: At 10,000 feet (3,300 meters) with Pinus teocote in addition to the above occur Pirola rotundifolia, Chimaphila maculata, Woodwardia ciliata (= Cheilanthes marginata), Acrostichum Schiedei (= A. rubiginosum) and A. simplex and certain arborescent Ericaceae: Arbutus floribunda, A. laurina, A. paniculata, A. Menziesii.

The following plant grows on the dry rocky walls: Echeveria (Cotyledon) mucronata and ferns of the genera Asplenium, Nephrodium (Aspidium, Dryopteris), Notholaena, Adiantum, Cheilanthes, Polypodium together with species of Pinguicula, Stevia, Senecio, Baccharis and Valeriana plantaginea.

In the upper timber belt are found Pinus strobiformis (= Ayacahuite) and P. Hartwegii, which range to about 14,000 feet and perhaps two to three hundred feet higher on the adjacent Sierra Negra. At 13,200 feet, these trees form groves, or thickets, 30—40 feet high. The belt of the Mexican mountain fir, Abies religiosa, on this mountain ceases at an elevation of 11,500—12,000 feet. Juniperus tetragona covers the bare rocks of Mount Orizaba at some little distance beyond the actual tree line. On such rocks above tree line, according to LIEBMANN (loc. cit.), are found mosses and lichens of the genera Bartramia, Pohlia, Lecidea, Bryum, Didymodon, Trichostomum and Stereocaulon.

*Alpine Formation.* At about 12,000 feet, where the exposure and slope is such as to inhibit the growth of trees, for example, along the edges of barrancas, occur grassy stretches characterized by *Pedicularis Orizabae*, *Eryngium proteaeflorum*, *Stenanthium frigidum*, *Cerastium vulcanicum* and *orithales*, *Arenaria leptophylla*, *Ranunculus geoides*, *Nasturtium orizabae*, *Draba tolucensis*, *Stevia purpurea* and *arbutifolia*, while along the courses of mountain rivulets occur species of *Carex Barbarea*, *Juncus*, *Luzula* etc. Above 13,600 feet, the grass belt becomes the feature of the mountain extending to snow line. A number of plants disappear at the lower edge of this belt, viz., *Acaena elongata*, *Poa annua* and *Bryum argenteum*. The grassy covering consists of *Festuca tolucensis* and *livida*, *Trisetum elongatum*, *Deyeuxia recta*, *Epicampes macroura* (= *Crypsis stricta*), many *Agrostis*- and *Festuca*-species. Here exists an Andean genus of Ericaceae (see ante p. 302): *Pernettya ciliaris*, on dry sandy soil.

The marshy places formed by the melting of snow water are inhabited by Ranunculus reniformis which with a species of Potentilla renders such areas of a yellow color associated with Phleum Haenkeanum (= P. alpinum) and species of Veronica, Agrostis and Luzula.

The rocky aiguilles are covered with Berberis (Mahonia) ilicina and Juniperus tetragona, while the botanist observes here such cryptogams as Parmelia encausta, P. centralis, Evernia furfuracea, Lecidea atro-alba, Lecidea atrovirens, Umbilicaria pustulata (10—14,000 feet), U. vellea (13,000—14,000 feet), U. cylindrica and U. proboscidea between 14,000 and 14,800 feet. At this elevation, the landscape is forbidding, for the grasses stand in isolated clumps in serried rows with the light loosely compacted volcanic ash and scoria filling the places between and covering all the vegetation with a grayish mantle. Here and there, however, the monotony of the scene is relieved by some projecting rock mass, the vegetation of which has just been described.

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1) SEATON, HENRY, E.: Plants collected on M. Orizaba 1891: see Bibliography p. 86.

The herbaceous plants which extend their growth to an elevation of 12,000 to 15,000 feet on Mount Orizaba are, according to HEILPRIN[1]: Ranunculus peruvianus, Draba myosotidioides, Arenaria bryoides, Potentilla Richardii, Heuchera orizabensis, Peucedanum tolucense, Senecio chrysactis, S. multidentatus, S. orizabensis, Hieracium niveopappum, Lobelia nana, Arctostaphylos pungens, Phacelia pimpinelloides, Mimulus glabratus, Spiranthes ochracea and Stenanthium frigidum. The herbs that reach an elevation between 13,000 and 15,000 feet on Orizaba are: Draba tolucensis, Arenaria bryoides, Acaena elongata, Ribes jorullensis, Stevia arbutifolium, Senecio cirsoides (= S. roseus), S. gerberaefolius, S. procumbens, Cnicus nivalis, Pernettya ciliaris, Veronica serpyllifolia, Castilleja tolucensis. The last plant to disappear on Orizaba peak is Castilleja tolucensis and a Draba (D. aretoides, or D. popocatepetlensis) both of which, according to HEILPRIN, follow close to snow line, or nearly to 15,000 feet. On the blocks of rock above 14,600 feet where, according to LIEBMANN, the last flowering plant occurs, grow a lichen, Rhizocarpon (Lecidea), geographicum and a moss Grimmia apiculata, while here also occur Tortula ruralis, Parmelia Ehrhartii, Lecidea atro-alba, L. vitrina and above all these, as the last plant, Parmelia elegans.

**Popocatepetl.** The belt of cactus, nopal, mesquite of the Mexican plateau is replaced higher up on Mount Popocatepetl by a belt of pines (Coniferous Forest Formation) consisting of *Pinus Montezumae*, *Pinus Teocote* and *P. pseudostrobus* at an elevation above 9,000 feet. These long-leaved pines are replaced by short leaved pines. *Pinus strobiformis* and *P. Hartwegii* which reach to approximately 13,000 feet, (13,160, according to HEILPRIN), the trees being of inconsiderable heights. *Lupinus vaginatus* extends to 13,000 feet. *Senecio chrysactis* reaches the limit of the pines on all of the loftiest mountain summits forming with the lupine a compact undergrowth to the pines, especially where the latter have been thinned into groves leaving patches of open country in their midst. Here the vegetation is most luxuriant and the eye revels in the brilliancy of colors which are everywhere manifest.

Alpine Formation. Beyond the limit of trees (above 13,000 feet), the vegetation continues over the slopes as a long wiry grass to a point 500 feet higher[2], although the sands blown about by the winds frequently cover the grass and choke it. The grasses which occur above timber line (13,000 feet) are: Sporobolus Wolfii (just below timber line under the pine trees, Pinus Hartwegii), Stipa mucronata, Muhlenbergia quadridentata, Cinna (Deyeuxia) tolucensis, Trisetum Rosei var. tenerum, Trisetum tolucense, Poa conglomerata, Poa infirma, Festuca amplissima, F. aequipaleata, F. livida. The last grass and Trisetum Rosei were found by ROSE[3] associated together at 13,400 feet, Trisetum Rosei was found alone at 13,500 feet, the exact altitude at which Festuca livida was found on Mount Orizaba. This grass, therefore, holds the distinction of growing at a higher altitude than any other flowering plant on the North American continent, except Festuca livida. Both grow in and under the melting snow, pushing up along the tongues of sand, soon to be buried under a fresh fall of snow.

**Ixtaccihuatl.** The flora of this mountain is richer than that of Popocatepetl, according to Sonntag and Farrington. The succession of forest belts

1) HEILPRIN, A.: The temperate and alpine Floras etc.: see Bibliogr. p. 83; CROOK, A. R.: An Ascent of Mt. Orizaba. Pop. Sci. Month. 1902: 528—535; GADOW, HANS: Through southern Mexico 1908: 41—72 (Orizaba), 487—499 (Popocatepetl); see ante page 302.

2) FARRINGTON, O. C.: Popocatepetl and Ixtaccihuatl: see Bibliogr. p. 83.

3) ROSE, J. N.: Studies No. 4. 1905. 287—290: see Bibliogr. p. 85.

is, however, quite similar on the two mountains, the lowest consisting of laurels, pines and cedars, the middle of firs and the highest of pines.

The Coniferous Forest Formation grows more stunted until the limit of arborescent vegetation is reached at 13,123 feet (4,000 m). There, in the Alpine Formation at 13,200 feet, HEILPRIN found a veritable garden of plants, including *Castilleja tolucensis*, *Echeveria gibbiflora*, *Ageratum arbutifolium*, *Chionolaena*, *Phacelia pimpinelloides*, while from the rock-fissures protruded tufts of *Asplenium trichomanes* var. *majus*. Other plants accredited to the summit of Ixtaccihuatl are *Draba aretoides*, *Lupinus vaginatus*, *Oenothera tetraptera* and *Senecio salignus*.

**Toluca.** This mountain (15,091 feet) ranks fourth in point of altitude within Mexico. It rises by easy slopes and terminates in a vast bowl of a crater, its figure being a truncated cone, much depressed. The rim of the crater is ragged, showing several prominent peaks. Its southern slopes fall away rapidly to the tierra caliente and its middle slopes are covered with evergreen forests. Above the timber line grassy slopes extend up to the rim of the crater. The pine forest on this mountain, as before mentioned, consists of *Pinus Montezumae* with *Abies religiosa* in the cool wet ravines. — Above the timber-line according to PRINGLE [1]) are found *Eryngium proteaeflorum*, *Senecio Halleri* (in mats), *Castilleja densa* (in mats), *Festuca livida*, *F. ovina*, *Trisetum tolucense*, *Agrostis virescens*, *Calamagrostis orizabae* and a variety of *Deschampsia caespitosa*, while the absence of sedges is noteworthy. On the coldest steeps just under the summit, *Musenium alpinum* forms a dense sod in patches several feet broad: *Halenia crassiuscula* grows sparsely and *Draba jorullensis* more commonly. *Gnaphalium lavandulaceum* (= *Chionolaena lavandulifolia*) is a shrubby species on the summit ledges.

The oval crater of Toluca, a mile wide and two miles in length from east to west has five small lakes in its bottom. In the soft, bare soil on the margins of the lakes, rosettes of Calandrinia acaulis are common. On wet bottoms Alchemilla pinnata forms little patches of green, Oreomyrrhis andina (= O. andicola) forms mats, while Dissanthelium sclerochloides grows in scattered tufts an inch or two in height. Draba tolucensis occurs on the moist gravel, while in the shelter of rocks detached from above are found Gnaphalium popocatspecium. On the slopes above the lakes grow Plantago linearis and an Erysimum.

The following plants are accredited to Toluca: Draba tolucensis (8—14,000 feet), Erysimum macradenium (12—13,000 feet), Cerastium andinum (13,000 feet), Arenaria bryoides (14—15,000 feet), Geranium potentillaefolium (9—10,000 feet), Lupinus bimaculatus (12,000 feet), L. montanus (9—10,000 feet), L. vaginatus (12,000 feet), Ribes jorullensis (10—12,000 feet), Tauschia Coulteri (10,500 feet), Senecio procumbens (10—11,000 feet), Cnicus nivalis (11,400 feet) and Castilleja tolucensis (14,200 feet).

**Colima.** Twin peaks, known respectively as the Nevado de Colima and the Volcan de Colima, rise from a plateau covered with agaves, opuntias, *Argemone mexicana*, *Asclepias curassavica* and other plants to an elevation of approximately (in the case of the Nevado) 14,350 feet. A scattered forest

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1) PRINGLE, C. G.: Notes on Mexican Travel: see Bibliogr. p. 85.

of *Pinus Montezumae* reaches to the base of the summit rocks of the Nevado and mingling with the pines are oaks (*Quercus*), *Alnus acuminata*, *Salix lasiolepis*, *Arbutus varians*, while here along the borders of brooks grow *Arctostaphylos arguta*, *Clethra mexicana* [1]).

The pine forest which surrounds the Nevado is exactly duplicated at the base of the Volcan de Colima. The forest of pines is heavy, ascending to the edge of the lava beds and ridges, while the ashen gray summit of the peak is bare, the tree limit being found at 7,500 feet (2,500 m). Naked rocks and volcanic scoria make a scene of desolation unfit for the growth of trees species. On these lava fields are found species of Arctostaphylos and dwarf willows and occasionally a Yucca, while on the topmost ridges Ribes jorullensis (= R. ciliatum) forms thickets with Valeriana subincisa with soft, woody stems, six to fifteen feet long, reclining on the shrubs. The summits of mountain spurs are surmounted in places by thickets of Ceanothus azureus. — All the summit of the Nevado is covered with volcanic ashes and scoria, which do not offer conditions to plant life. Lupinus mexicanus (in great clumps), Pentstemon campanulatus, Castilleja lithospermoides, C. tenuiflora, Euphorbia campestris and Crypsinna stricta (= Epicampes macroura), a bunch grass, grow in the grassy openings of the mountain top. On the mountain crest beside the peak were found Vaccinium geminiflorum, Draba jorullensis and on the ledges a prostrate juniper.

## Chapter VI. North American Tropic Zone: Section of Mexico and Central America.

It is extremely difficult to give the characters which distinguish the tropics from other adjacent parts of the earth's surface. In general, the mean annual temperature is greater throughout the year than in other parts, but this alone is not sufficient to distinguish the tropics. In school texts on geography the statement has been made that the tropic zone lies on each side of the equator between the isotherms of 73° Fahrenheit (22,8° C), and the excessive heat and moisture of this zone produce a corresponding luxuriance of vegetation. MERRIAM on the other hand limits the tropic zone by considering the temperature control of the distribution of plants and animals. Tropic species, he thinks, require a total quantity of heat of at least 26,000° F. (14,400° C.); and, since the tropic life region is a broad equatorial belt, it is probable that both its northern and southern boundaries are marked by the isotherm showing a sum of normal positive temperatures of 26,000° F. (14,4000° C.). SCHIMPER finds that the characterization of the tropics depends on more complex data. The mean annual temperature of the air oscillates between 20° and 28° and in comparison with northern latitudes is fairly uniform; even the difference of the highest and lowest temperature of the year in the equatorial zone does not vary much from the daily variation amounting on the average to 10—13° C. often much less, for example: 5° C. The general humidity of the air corresponds in general with the rainfall, being greater in the rainy season and

1) PRINGLE, C. G.: Notes on Mexican Travel, l. c. VII. 162, 172; KERBER, E.: see Bibliogr. p. 84; GADOW, HANS: Through southern Mexico 1908: 500—512.

less in the dry. The annual rainfall varies in the tropics between 2 and 5 meters in the mountains and a few centimeters in the deserts. The light ntensity also seems, from measurements that have been made, to be greater.

Notwithstanding the difficulty of accurately delimiting the tropics by climatic factors alone, it can be satisfactorily done by means of the plants, which have been influenced in their distribution and evolution by the interaction of the complex physiologic factors briefly mentioned above[1]. — The North American tropics comprise all of Central America, the narrow Atlantic and Pacific coastal plains of Mexico, the Greater Antillean, Bahaman and Bermudian islands with outlying southernmost peninsular Florida. Mexico has a tropic flora which was derived from the main mass of tropic vegetation of the present Central America, but originally from the flora of the disrupted Antillean continent after it was joined to the land mass lying south of the Isthmus of Tehuantepec. When the land bridge appeared, the tropic flora moved north along the Atlantic and Pacific coasts of Mexico some considerable distance. Two regions may be distinguished, therefore; the Jaliscan Region on the Pacific coast and the Gulf Region along the shores of the Gulf of Mexico. Then follow the Guatemalan Region and the Costa Rican Region of Central America.

## 1. Jaliscan Region.

Lying west of the main mass of the Cordilleras, the botanist might naturally expect to find a vegetation adapted to a dry or rainless climate, but C. G. PRINGLE informs me that about Ameca, Etzatlan and elsewhere, there is abundant vegetation with plentiful rains further west and little drought in summer south of Culiacan. Occasionally about Guadalajara, the country may be a desert, as late as May or June, but summer rains always fall there to bring about a good vegetation.

This region in the Mexican state of Michoacan is one of lovely lakes, such as Cuitzeo, Patzcuaro and Chapala (in Jalisco), while the Lerma and Balsas rivers drain a vast territory and empty into the Pacific Ocean. Grassy glades and undulating grassy hills are devoted to grazing, while outcrops of rugged rocks are covered with a scrubby growth of such small trees as *Acacia pennatula* and *Ipomoea muricata*. Salt marshes fringe the shores of Lake Cuitzeo, while under the ledges which line the shore is found *Malvaviscus acerifolius* and between the shore and the hills grow *Schinus molle*, *Prosopis juliflora* and the grotesque forms of *Ehretia mexicana*. The banks of slow

1) Der vorliegende "Survey" ist vornehmlich der Verteilung des borealen und des boreal-subtropischen Florenelements in N. Am. gewidmet. Er führt zwar die Einteilung in pflanzengeographische Zonen und Regionen auch für den kleinen, aber sehr wichtigen Anteil von N. Am. an den Tropen aus, doch gehört dessen ausführlichere Betrachtung mit derjenigen von Süd-Amerika (Columbien, Venezuela, Guiana, Amazonas &c.) zusammen. Die Beschränkung des Raumes hat daher zu einer sehr kurzen Bearbeitung der Verteilung von den Formationen in Chapter VI und VII führen müssen. DRUDE.

rivers are marked by *Taxodium mucronatum* and in deep barrancas by this tree and immense wild fig trees. The hills about Lake Patzcuaro are pine clad with oak and pine reaching to the mountain summits beyond, comprising a Forest Formation of such trees as *Pinus Montezumae*, *Quercus reticulata*, *Q. undulata* and *Arbutus varians*. On the ridges near Guadalajara are found *Pinus oocarpa* and *Quercus fulva*. *Vigna strobilophora* is a twining vine with a woody stem climbing to the tops of shrubs and low trees, while *Vitex pyramidata* is a small spreading tree found on rocky bluffs above Tequila [1]. *Eriodendron tomentosum* is a large tree which occupies the warmest barrancas.

The tropic portions of southern Michoacan is a mountainous area with scattered plains here and there. The plains are grass covered with irregular patches of scrubby trees and shrubs about their borders with a singular species of Agave on the bare sunbaked cliffs of canyons. The chaparral formation of this coast is found in the valley of the Balsas River and elsewhere. Here is found an abundant growth of various kinds of large cactuses, thorny shrubs and low trees which extend down to this coast. Near Acapulco are bold and rugged headlands with many large cactuses on their seaward faces [2].

The lagoons of the Jaliscan coast are characterized by the mangrove tree, Rhizophora mangle and associated species, but the absence of details precludes a more careful statement of floristic conditions.

## 2. Gulf Region.

The Gulf Region of Mexico comprises three distinct classes of formations: the coast littoral formations, the chaparral formations and the tropic forest formations.

*Littoral Formations.* Here we have ocean embayments characterized by such sea weeds as *Padina pavonia*, *Dictyota* spec., *Nemalion*, *Halimeda Opuntia* and *Sargassum Montagnei*; species which are usually found in shallow water with a bottom of calcareous sand [3].

According to my observations made at Tampico on the Gulf coast of Mexico, the sand-dune formation conforms to that of the American tropics in general. *Ipomoea pes-caprae* is the characteristic plant of the low dunes of this sandy coast trailing down upon the upper beach. Dunes occur along the north coast of Yucatan. Here occur *Bravaisia tubiflora*, *Croton punctatus* and in the shade of bushes *Beloperone violacea*, *Dicliptera assurgens* and *Euphorbia heterophylla* [4].

The Mangrove Formation is confined to lagoons which are formed primarily by a bar of sand forming across the mouth of some river. Rhizophora Mangle, Avicennia tomentosa and related species constitute the plants of this formation which extends in favorable places along the entire Gulf coast of Mexico and north coast of Yucatan, where Rhizophora, Coccoloba

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1) PRINGLE, C. G.: Notes on Mexican Travel in Michoacan. Garden and Forest VI. 263; in Jalisco VII. 152.

2) NELSON, E. W.: A winter Expedition in southwestern Mexico. National Geographic Magazine XV: 341—356. Sept. 1904.

3) VILLAGOMEZ, IGN. OCHOA: Vera Cruz. 1885: see Bibliogr. p. 87.

4) SELER, ED.: Zwei Frühlingsmonate in Yucatan. Festschr. zum 70. Geburtstage ASCHERSONS 1904: 371—382.

and such halophytes as Batis maritima, Lithophila vermiculata (= Gomphrena vermicularis) and Heliotropium curassavicum occur. —

The species of aquatic plants which exist in the lagoons (such as Tamulte and Ocuiltzapotlan) either submerged or floating are Vallisneria spiralis, Cabomba aquatica, Ceratophyllum, Potamogeton, Heteranthera graminea, Limnanthemum Humboldtianum, Villarsia Humboldtiana, Marsilia polycarpa, Nymphaea ampla, Eichhornia azurea, Pistia stratiotes, Jussiaea natans, Neptunia oleracea, Azolla caroliniana[1]. — The marshes, near such lagoons, are characterized by Typha angustifolia, Acrostichum aureum, Ceratopteris thalictroides, Thalia geniculata, Cyperus articulatus, Arundo and in salt marshes Scirpus maritimus. — The lagoons or morasses are distributed in Tabasco in all situations where depressions of the earth exist. These are frequently dry during the months of March, April and May. It is evident that this change influences the vegetation and in addition to the floating and submerged species, the botanist notes in such dry morasses Lonchocarpus hondurensis, Haematoxylon campechianum, Inga spuria, Dalbergia campechiana, etc.

*Chaparral Formation.* The chaparral formation extends into southeastern Texas where the character of the vegetation is controlled by a minimum of rainfall, a dry air subject to regularly recurring movements of great velocity and a high percentage of days of intense sunshine related to edaphic factors in which the soil has the loose, shifting, incohesive quality formed by dry weathering and destitute of vegetal mould, if not gravelly, or stony, and where the soil water level is too deep to be available for any but perennial plants with far reaching roots. The chaparral is typically a low, more or less impenetrable bush covering continuously vast areas, and varying in height from two or three feet to ten or fifteen, according to the ecologic conditions. In the lower Rio Grande country, the chaparral is rapidly encroaching on the prairie formations which were formerly more extensive[2].

On the basis of temperature, there is a distinction of species into those of semitropic and even tropic affinities and those able to endure the freezing winter temperatures of the warm temperate zone. The former occur chiefly in the lower Rio Grande country, the latter constitute the chaparral of the northern half of the plain, spreading also by some species into central Texas. Geologic structure and conditions of soil, according to BRAY[3], act powerfully to determine the facies of the formation upon any given area. Thus, gravelly slopes, denuded of finer sediment, may have a pure facies of straggling *Parkinsonia texana*, and basalt ridges are thickly covered by a short bushy facies of *Acacia Berlandieri*. It is noticeable that no less than 30 per cent of the number of species and a far higher percentage of actual individuals belonging to the leguminous suborders *Mimoseae* and *Caesalpineae*. The Gulf strip of Texas is approximately indicated by the range of *Acacia farnesiana* and *Parkinsonia aculeata*, both of these of tropic range.

BAILEY adds to these Daubentonia longifolia (= Sesbania Cavanillesii), Lantana camara, Amyris parvifolia, Karwinskia Humboldtiana, Maximowiczia Lindheimeri, Nymphaea elegans, Yucca

1) RAMIREZ, Dr. JOSÉ: see Bibliography p. 85.
2) BRAY, WILLIAM, L.: Forest Resources of Texas, p. 33; see Bibliogr. p. 75.
3) BRAY, W. L.: Botanical Gazette XXXII. 270—274: see Bibliogr. p. 75.

Treculeana, Tillandsia Baileyi, Jatropha macrorhiza, J. multifida, Malpighia glabra and Solanum triquetrum [1]. Sabal mexicana is found in limited numbers in the Brownsville neighborhood.

The Mesquite Facies or Association of Prosopis juliflora in the Rio Grande plain occupies the level areas of fine compact silty debris. It is often associated with Opuntia Lindheimeri. Similar "mesquite flats" as they are commonly called, are found in similar situations in the hotter portions of Texas but the species also occupy the black prairie soils in some areas. From San Antonio southeastward is a vast mesquite forest with trees ten to fifteen feet tall and in the lower Rio Grande valley individual trees attain a height of thirty-five feet and a diameter of two feet.

The Acacia Farnesiana Facies, according to BRAY, prevails on the low moister coast prairie clays. The species is more limited than the mesquite in both moisture and temperature requirements. Its spread has been on the coast prairie as far east as Galveston. — The Acacia amentacea Facies is the prevalent one in the northern half of the Rio Grande plain. Constituting sixty to seventy-five per cent of the shrubby vegetation on many thousands of acres, it is known as the "black chaparral". The Acacia Wrightii Facies is especially prevalent as an open one on grass plains in the northern part of the Rio Grande region between the Nueces and Medina rivers. The Huajillo Facies (Acacia Berlandieri) occupies the basalt ridges and cones extending east and west along the northern border of the region. Farther southeast, it has been noted on coarse gravelly ridges denuded of finer sediment and the trees scarcely exceed three or four feet in height. Parkinsonia texana, found on the coarse gravelly slopes near Eagle Pass, is an habitually procumbent or straggling shrub which, while occupying the ground fully, is a very diffuse covering. — The more arid parts of the Rio Grande country especially within twenty miles of the river on both the Texan and Mexican sides are occupied by a solid mass of Leucophyllum texanum which on account of a hairy felt covering the leaves gives it a light tone conspicuous to the uninitiated eye.

*Mixed Coast Chaparral Formation.* From the mouth of the Rio Grande to Corpus Christi, the coast is low, mostly bare and unattractive. The trees which occur here, are *Prosopis juliflora*, *Acacia farnesiana*, *A. flexicaulis*, *Parkinsonia aculeata*, *Diospyros texana*, *Celtis mississippiensis* var. *reticulata*. The scrubby chaparral [2] extending from the shore inward for several miles, consists mostly of *Prosopis juliflora*, *Diospyros texana*, *Acacia amentacea*, *Condalia*, *Castela*, *Zanthoxylum*, *Lippia lycioides*, *Lantana camara*, *Berberis trifoliolata*, while the vines comprise *Anredera*, *Vitis*, *Serjania*, *Maximowiczia*.

The chaparral, which we have outlined as characteristic for southern Texas, extends southward along the coastal plain of Mexico. It reaches a considerable width, according to my observations, west of Tampico in the low flat, hot country, but owing to absence of information its exact extent cannot be given for other parts of eastern coastal Mexico. Upon reaching Yucatan, however, this formation which forms such a conspicuous part of the vegetation in nearly all the arid regions of the earth (Argentina and Chili, central South Africa, Australia, etc.) spreads out and occupies the country to the exclusion of most other vegetation. The arboreal elements which comprise the scrub which covers most of Yucatan are leguminous, according to HEILPRIN [3] and SELER.

1) BAILEY, V.: see Bibliogr. p. 75.

2) HAVARD, Dr. V.: Report on the Flora of western and southern Texas. Proceedings U. S. National Museum VIII. No. 29. 1885: 485.

3) HEILPRIN, A.: Flora of northern Yucatan; see Bibliogr. p. 83. — SELER, l. c.

In the mountain region forty to sixty miles south of Merida, or beyond Ticul, certain new elements are introduced into the vegetation, which impart to it a somewhat distinctive character; but, broadly speaking, the flora is still that of the northern limestone flats, with its chaparral species as the dominating feature. At several points on the northern flank of the sierra, there are extensive growths of the red gum, the chakah of the Mayas, *Bursera gummifera*, destitute of leaves in the dry season, while in the thinner jungle occurs *Bromelia pinguin*.

*Tropic Forest Formations.* These forest formations cover the area of Mexico, which after the removal of the original native vegetation is devoted to the cultivation of the sugar cane, banana, coffee, rubber tree, mango, orange, papaw, alligator pear, and other tropic economic plants, adapted to a steaming, hot, humid climate. In the neighborhood of Papantla in the state of Vera Cruz in the heart of the tropic forest is the seat of the vanilla industry of Mexico. Tree after tree in this vast forest is covered with the luxuriant vines of the vanilla orchid, *Vanilla planifolia*, indigenous to these wilds. It is with this tropic forest, which the writer has seen at three places (Rascon, Cordoba and Orizaba), that we are now concerned.

The forest composed of numerous species is thick, the undergrowth is dense and trees and shrubs, according to my observations in the Tamasopo Canyon, are bound together by clambering vines to form an almost impenetrable jungle. Each large tree in the descriptive language of PRINGLE[1]) with huge spreading branches and leaning trunk becomes a garden of plants. On its rough mossy surface are found ferns, orchids, bromeliads and cactuses. Not epiphytal plants alone are found in such situations, but almost any herb, or shrub, which grows in the neighboring soil. The most abundant tree of these tropic forests is doubtless *Ficus segoviae* associated with *Quercus germana*, *Dendropanax arboreum*, *Banara mexicana*, *Zanthoxylum Pringlei*, *Clethra Pringlei* and a host of others.

At an altitude of 2,000—3,000 feet in the neighborhood of Orizaba, several species of oak occur: Quercus polymorpha, Q. tomentosa and Q. obtusata, all trees of small dimensions, having small rigid, usually wooly leaves. At 3,000 feet, the oak trees become larger and form dense forests with the following oak species: Q. jalapensis, Q. calophylla (= Q. alamo), Q. polymorpha, Q. lanceolata, Q. Ghiesbreghtii. Beneath the shade of the oaks grow various species of Chamaedorea and on their roots the scarlet Monotropa uniflora (= M. coccinea) and Conopholis silvatica (near C. americana). A variety of woody climbers occur, belonging to such genera as Banisteria, Paullinia, Serjania, Smilax, Rubus and Vitis. On the outskirts of the forest grows an elegant bamboo, Arundinaria acuminata. At an elevation of 4—5,000 feet higher on the mountain sides, dense forests exist in which Quercus Galeottii, Q. insignis and such evergreen species (leafless during the short continuance of the violent northerly winds) enter as important elements. Many elegant epiphytes grow in these forests, such as Juanulloa parasitica, Columnea Schiedeana, various orchids and bromeliads[2]). At an altitude ranging from 6—7,000 feet, pines begin

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1) PRINGLE, C. G.: l. c. On the Tampico Branch. Garden and Forest VI: 203.

2) HEMSLEY, W. B.: See GODMANN & SALVIN in Bibliogr. p. 83, IV: 261; LIEBMANN, translation in HOOKER's Kew Journal Botany IV (1852): 321.

to mingle with the oaks; yet the latter still predominate and constitute the bulk of the forest. Such oaks as Quercus lanceolata, Q. laurifolia, Q. glabrata mingle with Ostrya, Tilia, Salix and Cornus. Above 7,000 feet, the oaks are gradually replaced by pines and elevations of 8—10,000 feet, such species as, Quercus spicata, Q. reticulata, Q. chrysophylla and Q. pulchella are found scattered among the pines.

In this forest region with a temperature of 70° and favored by the long rainy season, the richest vegetation of Mexico exists and orchids reach their maximum with some two or three hundred species, some terrestrial, but mostly epiphytal[1]. At 4,000 feet, according to my observations, I found forest trees the limbs of which had been broken off by the weight of epiphytes consisting of Epidendrums (E. virens), Tillandsias, Cereus triangularis, Phyllocactus grandis, Polypodium aureum and others. At San Antonio, Huatusco and San Bartolome, oaks reach their highest development, not only in the number of species but also in their size. Associated here with the oaks, grow trees of the orders Lauraceae, Myrtaceae, Anacardiaceae and Anonaceae with an undergrowth consisting of tree ferns, Lygodium, Zamia and species of Citrosma, Acacia, Mimosa, Yucca, *Triumfetta*, *Jatropha*, *Croton*, *Magnolia*, *Symplocos*, *Aralia* and *Aesculus*. Liquidambar styraciflua has a very definitely defined vertical area lying between 3,500 and 5,500 feet. Platanus mexicanus only grows by running water at 4,500 to 5,500 feet at the upper limit of the tropic forest. Piper umbellatum climbs into the trees, according to my observations at Orizaba.

In the midst of these forests of tall trees, belonging to the families Leguminosae, Sapotaceae, Malpighiaceae, Meliaceae, according to H. GALEOTTI[2], are found growing as epiphytes Stanhopea tigrina, S. saccata, Maxillaria (Lycaste) aromatica, Epidendrum ancipticaulon, E. rigidum, E. Candollei, Pleurothallis microphylla, Oncidium sphacelatum, O. stramineum, Coelia Baueriana, Galeottia (Zygopetalum) grandiflora and Ponera striata.

The tropic forest in Yucatan is not extensive. HEILPRIN[3] found near Sitilpech on the Camino Real to Valladolid a forest of tropic luxuriance. The large trees *Inga xylocarpa* and others of it are decked with orchids and epiphytes among which are species of *Epidendrum*, *Cattleya*, *Tillandsia*, *Cereus*, *Oncidium*. Among other components of the vegetation may be mentioned *Yucca*, *Furcraea*, *Cereus grandiflorus*, *C. flagelliformis* associated with *C. peruvianus* and other species in dense and impenetrable thickets.

Palm Forest Formation. About Rascon on the Tampico branch of the Mexican Central railroad, according to my observations occurs an almost pure formation of a fan palm Erythea edulis (see Fig. 32), forty to fifty feet tall and covering many square miles of level country and mountain ridges, in places associated with a tall and flexuous species of bamboo. Alternating with these palm forests are open meadows, which lead back between hills whose sides are grassy glades and whose summits are covered with oaks. The country is intersected by rivers along which are swamps, meadows, river jungles in endless succession, unexplored by the botanist and unknown.

## Central American Regions.

The following region is a distinct one, for the reason that phytogeographically it stands intermediate between the South American phytogeographic

1) HEMSLEY, W. B.: Biologia Centrali-Americana. Botany IV: 146.

2) RAMIREZ, DR. JOSÉ: La Vegetacion de Mexico. 1899. Pages 15—26 where the details of the orchid distribution in Mexico are given.

3) HEILPRIN, A.: Flora of northern Yucatan; see Bibliogr. p. 83.

sections on the one hand and the Mexican on the other. On account of its deserts, the Mexican tropic territories are easily separated from the Central American countries, which although showing in their flora close affinities to that of South Mexico, yet do not possess an alpine mountain flora, such as occurs in Mexico. Then too, the Central American vegetation includes many South American types, which do not reach southern Mexico [1].

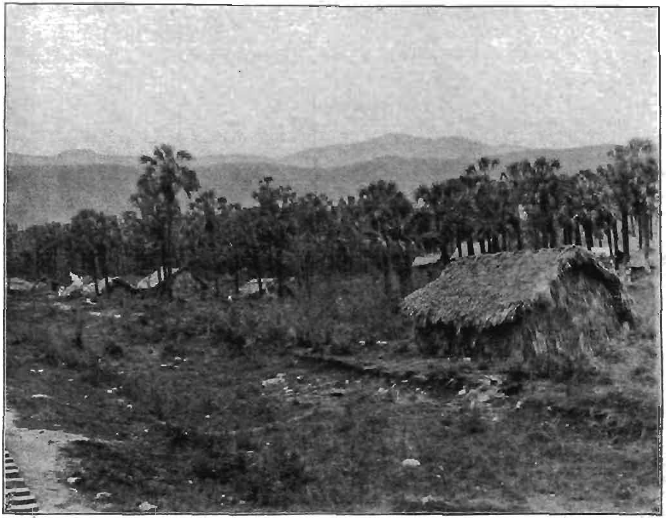

Fig. 32. *Erythea (Brahea) edulis* S. Wats. growing at an altitude of 1,000 feet (300 m) near Rascon, State of San Luis Potosi, Mexico.

## 3. Guatemalan Region.

This region comprises the political states of Chiapas (Mexico), British Honduras, Guatemala, Honduras, Salvador and northern Nicaragua, and, with a diversified topography, situated in the tropics has a correspondingly rich flora arranged into a number of well characterized plant formations. Lowland plains exist, elevated tablelands occur and several high mountain peaks, described in Chapter I, page 117. —

The Mangrove Formation (*Rhizophora mangle* and associated species) occupies a narrow strip along the Atlantic and Pacific coasts of this region,

1) Cfr. map by CALWERT, P. P.: Proc. Acad. Nat. Sci. of Phila. 1908: 460—491, plate XXVI.

especially on the Gulf side along Honduras Bay, Rio Dulce, Caratasca Lagoon, the deltas of the Prinzapolca, Cuculaia and Coco rivers and on the Pacific side in the Gulf of Fonseca. The shores of Utila and Ruatan islands are also mangrove fringed. The plants of this formation are essentially the same as for the formation in Mexico.

### 1. Forest-, Chaparral- and Savannah Formations.

*Tropic Rain Forest Formation.* Two types of the tropic rain forest exist, one which covers the plains and shows transition to tree savannas and another type, subtropic and tropic, which covers the mountains or sierras of the country. These two types may be considered to constitute one formation which covers a large part of the state of Chiapas in the drainage basin of the Usumacinta River and its tributaries the Rio Lacantun, Rio Chixoy, the northern part of Guatemala extending around the Sea of Yzabal into Honduras where it covers an irregular territory located in the basins of the Rio Motagua, Rio Ulua, on the Sierra de Omoa, Sierra del Espiritu Santo and along the north coast in a broad strip between the parallels of 84° 30′ and 87° 45′ W. longitude. This formation covers almost completely the country in eastern Honduras situated between the 84° and 86° W. longitude and 12° 30′ and 15° 30′ N. latitude, while it extends also into northern Nicaragua. In Guatemala on the Pacific coast, it forms a narrow strip inside of the coastal savannas. Along the Sierra de Olancho and Sierra de Misoco, two broad tongues of this formation enter the oak and pine forest formation.

The forest of the tierra caliente is one of much richness. In Honduras, according to MORRIS[1]), nothing so impresses the traveller as the profusion and diversity of palms including an abundance of Oreodoxa oleracea and Euterpe edulis, both West Indian palms of which we have no other evidence of their occurring in Central America. Other prominent genera are Attalea (A. Cohune at San Pedro, Honduras, see plate V at p. 304) Bactris, Geonoma, Thrinax, Sabal, Acrocomia, Acanthorhiza, Desmoncus and Chamaedorea, several of them like the last being represented by a number of species. Swietenia mahagoni, wild Theobroma cacao, Cedrela odorata, Guaiacum officinale, Achras sapota, Leucaena esculenta, Castilloa elastica, Haematoxylon campechianum, Ceiba pentandra, Morus tinctoria enter into the composition of this forest. A useful indicator of climate is the Taxixco, Perymenium Tuerckheimii, a tree which is confined in Alta Vera Paz to elevations between 700 and 1800 meters and which occurs in tropic and subtropic rain forests. On the Pacific slopes, it occurs up to an elevation of 1600 meters because the Pacific climate is less moist than that of Alta Vera Paz. Elsewhere this tree is found, as at San Pedro, at an elevation of 2100 meters. — Liquidambar styraciflua is also useful as an index of climatic conditions for in Alta Vera Paz, Baja Vera Paz and in Zacapa, it grows at elevations ranging from 800—1,900 meters. These two trees are characteristic ones for the tierra templada.

Orchids are represented by the genera Oncidium and Epidendrum, Gongora, Chysis, Maxillaria, Catasetum, Mormodes, Coryanthes and Dichaea; the most common are Schomburgkia tibicinis and Epidendrum bicornutum growing in the greatest profusion, even within reach of the salt spray from the sea. Each tree has its branches loaded with orchids and bromeliads and its trunk festooned with climbing aroids, ferns and mosses.

1) HEMSLEY, W. B.: Biologia Centrali-Americana. IV: 151—152.

Cohune Ridge Formation[1]). Between the pine ridges and the rivers are what are called cohune ridges in consequence of the predominance of the noble cohune palm, Attalea cohune (see plate V at p. 304). The distribution of this palm is affected by the near presence of running water, for it often monopolizes the banks of rivers and is not so generally represented farther away. It is found vegetating in clumps, small and large together, over which are masses of thick, woody creepers. Associated with this tree is the mahogany, Swietenia mahagoni. Ferns are abundant in the shady depths of this forest though there appears to be only one tree fern, Alsophila. —

*Pine Ridge Formation.* The tree which occupies almost exclusively the dry gravelly soil of the broken ridges is *Pinus caribaea* (= *P. heterophylla* = *P. cubensis*), a species which has the northern limits of its distribution in South Carolina. Except in the narrow valleys, the forest of this pine is a fine one. One hundred and one trees have been counted to the acre and the growth is tall and straight. In some places, the pine ridge plants give place to groves of oak, probably *Quercus virginiana*, and some of these oaks attain great size. This pine ridge formation, according to SAPPER[2]), occurs in British Honduras on the central Monkey River, in Guatemala southeast of Lake Peten, on the shore of the Sea of Yzabal. In Honduras, the pine ridges occur in isolated localities such as at Trujillo on the north coast, while stretching from the Brus Lagoon on the north shore to the Rio Grande (Nicaragua) in latitude 13° is a broad continuous strip characterized by the dominance of the plants of this formation alone. This strip reaches its greatest width on the Coco River (Nicaragua) extending from the littoral forest on the east to the tropic rain forest at S. Geronimo on the west. In general the littoral forest bounds the forests of *Pinus cubensis* on the east and northeast, but in several places the tropic rain forest is interposed. On the Pacific slope this formation is not represented.

*Pine- and Oak Forest Formation.* This formation in large part covers the south central part of Guatemala equally on each side of the 15° north latitude, extending into the province of Huehuetenango quite to the 16° north latitude with an eastern arm following the Rio Motagua beyond the Sea of Yzabal. Southeastward, this formation extends into San Salvador, north of the Savanna Chaparral formation. The whole of the central part of Honduras, as far east, as west longitude 85° 30′ is occupied by the oak-pine forest, except where its continuity is broken by savannas, chaparrales, tropic rain forests and the like. In general, this formation occupies a country with a pronounced dry climate conditioned by the direction of the mountain chains which influence the distribution of rain. The drier the local climate, the more does the pine predominate over the oak, and conversely, but in Honduras the pines seem to be more widely distributed than in Guatemala.

The rainfall in the region of oaks and pines is between one and two meters yearly, but this amount may be modified by local conditions. On the Pacific slopes of the mountains 500 m

1) HOOPER, E. D. M.: See Bibliography p. 84.

2) SAPPER, K.: See Bibliography p. 86: Guatemala: see Bibl. p. 85.

may be considered the lowest elevation at which the pine trees grow[1]), whereas in the north the lowest limit of the pine timber is about 100 m above sealevel. In many situations in the savannas, the air temperature is sufficient to permit the growth of pines, which appear in single groups, or in large groves (savannas with pines).

*Dry Tropic Forest Formation.* Along and in the neighborhood of the Pacific coast, whither the moist air currents from the ocean occasionally impinge even in the dry season, occur primeval forests, which reach only the thickness of the tropic rain forests in the north, where the forest trees assemble themselves along the banks of rivers, or rapidly flowing streams. These dry forests differentiate themselves from the tropic rain forest in the north by the presence of numerous trees with a periodic leaf-fall, through the extreme scarcity of lianes, epiphytes and palms, and through the absence of tree ferns[2]).

The relative poverty of undergrowth is a marked feature, and where it is found, it consists largely of succulent plants. Many times the sole undergrowth consists of bromeliaceous plants (typically in Salvador where these forests have their most pronounced distribution than in southern Honduras). In places, this forest formation merges with the savanna formation, thus constituting along the line of tension, a tree savanna.

Where the rainfall is greater this forest formation grades into the wet forests of the plains where, as in southern Salvador, it is impossible to clearly demarcate them. The boundary line, however, is well marked where the primeval tropic rain forest comes in contact with savannas, or pine ridges, elsewhere the lines of contact are more difficult to establish on account of the dovetailing of one formation into another.

The Chaparral Formation, consisting of a dry forest of small-leaved trees of short stature with thorns is widely distributed in considerable areas throughout the Guatemalan Region.

The chaparral vegetation consists of species of Acacia, Crescentia, numerous cacti (Opuntia, *Mamillaria, Cereus*) and in high elevations species of *Agave*.

There is an arid region supporting purely xerophytic vegetation in the central part of the country beginning at Gualan, 80 miles (129 km) from Puerto Barrios in the valley of the Motagua extending to El Rancho 130 miles (209 km) from Puerto Barrios, according to W. A. KELLERMAN, thence westward and north-westward through Salama. Tree cacti of the Cereus, Opuntia and Peireskia types are the characteristic forms together with Leguminosae, *Swietenia mahagoni*, Ficus trees etc. The grasses and other vegetation seem to be absolutely dead during the dry season, but when the rains begin in the spring everything becomes intensely green. At Zacapa, the vegetation is of a pronounced xerophytic type, tree cacti are abundant and Acacia- and Mimosa bushes are common together with numerous short-stemmed, matted grasses.

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1) SAPPER, K.: Beitr. phys. Geographie von Honduras, see Bibliogr. p. 86; also the important paper by O. F. COOK: Vegetation affected by Agriculture in Central America. Bull. 145 U. S. Bureau of Plant Industry 1909.

2) SAPPER, K.: Beiträge zur physischen Geographie von Honduras p. 149.

*Savanna Formation.* In Peten in the northern part of Guatemala are great grass covered areas called sabanas by the natives. Small groups of Coyol palm, *Acrocomia vinifera*, and other trees dot over the surface of these savannas. In general, the savannas are in the middle of the lowlands between the Caribbean coast and the mountains. The coast rains are well known, but as the winds go over the interior plains without ascending, these plateaux are therefore in a partially dry belt, so that for several months in the dry season no rains occur.

Consulting the maps of SAPPER, it is found that the savannas dotted over with trees are located inside of the littoral forest along the whole Pacific coast of Guatemala, extending into Salvador and Nicaragua with finger-like extensions into the interior of the country along the valleys of the principal streams. Here the vegetation of this formation mingles with that of the oak-pine forests. Elsewhere the savannas occur in the interior, but never covering a large amount of territory.

Another type of savanna called "pajales" exists in regions of relative dryness, where except the small strips of timber along streams and the small clumps of bushes and isolated pine woods cover the mountains and valleys in some parts of Alta Vera Paz. It lies, as other savanna islands on the leeward side of mountains, thus cut off from an abundant rain supply.

Sabinas Formation. Little information is available concerning this formation except a short note by SAPPER that the sabinas, Taxodium mucronatum, forms pure growths in Huehuetenango, where it reaches its most eastern distribution.

## 2. Plant Formations on Central American Volcanoes.

The summit of Volcan de Agua (about 12,400 or 13,500 feet), is clothed with grass and a few pines, together with alpine shrubs (Vaccineae, *Lupinus* etc.) up to the summit[1]; but Volcan de Fuego, the highest peak of Guatemala (12,655 feet) owing perhaps to the looseness of the scoriae, is nearly barren. The sparse vegetation here consists of ferns, lycopods, etc. fixed in the crevices of the rocks. Lower on both volcanoes, the pine trees become larger and more numerous, down to an elevation of about 10,200 feet, where they cease suddenly and give way to a dense mixed forest of which *Cheirostemon* is one of the most characteristic trees. Large evergreen oaks are prevalent at 7,000 to 8,000 feet[2]). The Volcan de Atitlan (11,564 or 12,000 feet) somewhat resembles the Volcan de Agua and Volcan de Fuego, but the zones of vegetation are not so clearly marked. Above 3,500 feet, where coffee cultivation encroaches, a rich forest prevails on the southern slope through a large portion of which is a beautiful undergrowth of small palms. The summit of this mountain is nearly bare because the volcanic ash prevents plants from getting a foothold there, but a few plants are to be found in the crevices of the rocks fostered by streams issuing therefrom.

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1) KELLERMANN, W. A.: Journal of Mycology XII: 137.
2) HEMSLEY, W. B.: Biologia Centrali-Americana. IV: 152—154.

The Volcan Santa Maria (12,457 feet) in the Department of Quezaltenango is likewise clothed with forest vegetation which reaches the summit. The eruption of 1902 completely destroyed the vegetation on the south and southwest side where a new crater of immense size was formed.

Above 2,700 meters, the trees of the tropic rain forest appear no more, but the forest forming a Mixed Mountain Forest Formation consists of broad-leaved and coniferous trees, such as oaks, alders, pines, spruces and cypresses. The undergrowth consists of species of Vaccinium and shrubs of myrtle form. Many stems in this forest are decidedly mossy with a growth of epiphytic mosses. Mountain meadows occasionally interrupt the continuity of this forest formation as at Chancol and Rosario (3,100 meters).

Above the tree limit, as on Tacana (13,364 feet = 4073 m) and Tajumulco (13,814 feet) the botanist finds a Treeless Grassland Formation, grassy stretches characterized by low flowering plants mostly found at the top of precipices, the sides of waterfalls, or wherever the sun can reach the ground. At places where large wet surfaces of lava have no covering of soil, they are carpeted over with thick beds of mosses and ferns. The upper limit of flowering plants or the border of the eternal snows is never reached on any of the volcanoes of Central America. The summits of Atitlan and Volcan de Fuego are without vegetation, while the peak of Pacaya is covered by a sparse flora. Between 3,700 and 3,800 m is the upper limit of the coniferous forests. Single twisted specimens of sterile pines ascend on the moist southeast declivities of Volcan Tacana and Tajumulco to 3,980 meters, while the tree limit is much less elevated on the north and northwest slopes of the mountains.

## 4. Costa Rican Region.

This southern floral region of the Central American Tropic Section, comprising southern Nicaragua, Costa Rica and Panama, exhibits a close relationship with the South American Tropic flora. The composition of the Panama flora as far as investigated is decidedly South American. For example, according to HEMSLEY[1]), the Dilleniaceae and Anonaceae thin out northward. The eastern South American order *Lecythidaceae* is represented by four genera and seven species, one of which reaches Nicaragua, its northern limit. *Podocarpus* with two species (*P. taxifolia* and *P. salicifolia*) replaces *Pinus* in the mountains of Costa Rica. The southern limits of such northern types as *Liquidambar*, *Sabiaceae* and *Juglandaceae* are reached in Costa Rica. *Arbutus* and *Arctostaphylos* are replaced by South American genera of the Vacciniaceae in the mountains.

The Nicaraguan Hylaea of POLAKOWSKY[2]) which includes the forests of the basin of the Rio San Juan and the southern shores of Lake Nicaragua can be taken, as the boundary country separating the cis-equatorial flora from that of Guatemala and Mexico. It may be said to represent the line which delimits the North American flora proper from that of South America. Therefore, we have here to consider this region only as an annex to the foregoing regions.

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1) HEMSLEY, W. B.: Biologia Centrali-Americana IV: 313.

2) POLAKOWSKY, H.: Pflanzenwelt von Costa Rica; see Bibliogr. p. 85; Cfr. RIDGWAY, ROBT.: Condor VII: 151—160.

Such types as Pinus, the Cactaceae, the Piperaceae are little represented in the flora of Costa Rica and still less in Panama. The flora of the highlands of Costa Rica shows affinities with that of Mexico and may be considered to be a southern extension of Mexican types mingled with those of a different region. The primeval forests on the eastern slopes of the Cordilleras consist of plants represented in the flora of Columbia and Venezuela, while that on the Pacific coast of Costa Rica is essentially the same as in Panama [1]). The flora of Chiriqui is essentially the same as that of eastern tropic South America, except in the higher regions between 8,000 and 9,000 feet where, as we have seen, a certain number of species occur which are either common to Mexico and Guatemala, or peculiar. The characteristic species which enter into the Chiriqui flora, as well, as the whole of the Costa Rican phytogeographic region, approach most nearly to those of Brazil, Guiana and the coasts of Venezuela and Columbia. Species in common with West Indian ones are also found. The Chiriqui flora has very little in common with Guatemala and Mexico and still less with Ecuador and the Andean highlands [2]). Lastly, we have no knowledge of any species of *Yucca*, *Nolina*, *Dasylirion*, or *Beschorneria* south of Guatemala; and records of these genera, as well as for *Furcraea* and *Agave*, are very few for the territory south of Mexico. The last two genera probably enter the Costa Rican region, yet the evidence of such distribution is scanty. The following formations contain examples of the mixed character of the South American type of the Rain Forest Formation with the North American one of oaks and alpine elements.

*Hylaea Formation.* The entire territory drained by the San Juan River in Nicaragua is covered with tropic forests of extreme density and impenetrableness. The trees are very tall and from eight to fourteen feet in diameter, not placed so closely as in our northern forests, but the spaces between are covered with shrubs and vines and numerous other plants together with parasites and epiphytes (ferns, bromeliads, mosses) which cover the branches and trunks of the trees [3]). On account of the unusually luxuriant character of the vegetation, POLAKOWSKY [4]) suggests the name Hylaea for this type of forest growth and this name Pittier applies also to the entire Atlantic forest of Costa Rica, attributing to it a South American character.

The Atlantic slope with more constant humidity of air is characterized by vast, dense, evergreen, virgin forests (Tropic Rain Forest Formation). The tangle of vegetation is so great that the interior of the country can be

1) POLAKOWSKY, H.: Petermanns Mitteilungen 1877: see Bibliogr. p. 85.

2) WAGNER, DR. MORITZ: Physisch-geographische Skizze der Provinz Chiriqui. Petermanns Geographische Mitteilungen 1863 pp. 280—299, translated by HEMSLEY.

3) SHIMEK, B.: A Forest in Nicaragua. Popular Science Monthly 1894. XLV: 857.

4) POLAKOWSKY, H.: Die Pflanzenwelt von Costa Rica 1879, loc. cit. p. 45; Also the important recent book and paper: PITTIER, H.: Ensayo sobre las Plantas usuales de Costa Rica, Washington 1908, and WERCKLÉ, CARLOS: La Subregion Fitogeográfica Costaricense. San José, Costa Rica. 1909.

reached only by way of the rivers. Owing to the mountainous character of the country, over half of its area lies between 900 and 2,100 meters above the sea and is almost wholly covered with virgin forest. This forest here and there ascends still higher, reaching the upper limit of the oak region about 2,700 meters above the sea.

The forest in the canal territory is of mixed growth, though the undergrowth contains a large element of low-growing species. The larger trees are *Ceiba pentandra* (= *Eriodendron anfractuosum*), *Hura crepitans*, *Cedrela*, *Erythrina* and a few others. As one gets further into the forest, *Castilloa* becomes quite common. Although there are few features to differentiate this territory botanically from other places in the same latitude, yet aroids and other climbing species are especially abundant [1]. As epiphytes growing upon the trees of this forest can be mentionned *Epidendrum rigidum*, *E. ciliare*, *E. radicans*, *E. piliferum*, *Odontoglossum Schlieperianum*, *Comparettia falcata*, *Peperomia tenerrima* and *Polypodium Friedrichsthalianum*.

Nowhere is the vegetation of these tropic forests more luxuriant than on the banks of the rivers. Wild fig-trees form great bowers over the streams, evergreen Pithecolobiums emit a fine perfume, bamboos display their feathery tops and groves of the vegetable-ivory palm are at places conspicuous. Many plants and orders of the lowlands begin to disappear between 2,000 and 3,500 feet in Panama; while tree ferns, grasses and showy orchids are conspicuous elements of the flora. The monocotyledonous undergrowth, the palms, cyclanthaceous plants, aroids and the genus *Heliconia* decrease considerably, while epiphytal orchids abound in the greatest variety. The Verbenaceae, Piperaceae, Papilionaceae, Compositae are as strongly represented as in the lower levels; while various Melastomaceae, Lauraceae, Tiliaceae, Clusiaceae, Apocynaceae and Vacciniaceae are peculiar [2].

*Oak Forest Formation.* At about 7,000 feet on Volcan de los Vatos Costa Rica, oaks predominate and *Podocarpus taxifolia*, *P. salicifolia*, *Drimys Winteri*, *Weinmannia* sp. occur. The sides of Volcan de Barba at 6,000 to 9,000 feet are covered with magnificent forests, consisting of oaks, *Cedrela odorata*, *Eugenia lepidota*, and laurels. The oaks are abundant above 7,000 feet. Here occur *Quercus virens* (= *Q. virginiana* = *Q. retusa*), *Q. costaricensis*, *Q. granulata*; species which become stunted at the summit of the volcano at 10,000 feet.

Towards the upper limits of the tropic forest, below the oak forest in Costa Rica, such palms as Chamaedorea, Geonoma, Euterpe longepetiolata, Bactris (Guilielma) utilis and Carludovica microphylla are seen in great abundance, mixed with such tree-ferns as Alsophila pruinata, Hemitelia horrida, H. grandifolia, etc. — The slopes of Volcan de Cartago or Irazu (11,500 feet) above 7,000 feet also possess the forest of oaks, where in addition to the oaks mentioned above grows Quercus citrifolia. The undergrowth consists of Cavendishia veraguensis, Siphocampylus Gutierrezii, Centropogon costaricanus, Myrtus Oerstedii, Hedyosmum calloso-serratum, Viburnum

1) COWELL: Explorations in Panama: see Bibliography p. 82.
2) HEMSLEY: Loc. cit. p. 166.

stellato-tomentosum, Ardisia irasuensis, A. laevis, Eupatorium ixiocladon, Oreopanax Oerstedianum, and at the upper limit of oaks Arctostaphylos rubescens and Buddleia alpina. — This oak forest on Volcan Irazu is very different from that either of Poàs, or Turrialba in Costa Rica. The remnant of this forest is a narrow belt of stunted oaks just below the ash-cone and it gives way to a rather scattered growth of small trees and bushes which become more sparse and small as the summit is approached. — The oaks on the mountains in Panama at 4,200—8,000 feet, discovered by Dr. SEEMANN, consist of Quercus glabrescens, Q. aristata, Q. bumelioides together with Alnus Mirbelii, an alder which extends north to Guatemala. Chamaedorea pacaya occurs in barrancas at 7,000 feet.

*Mountain Summit Formations.* (Including the "paramos".) At 10,000 feet the oaks are stunted and covered with *Usnea*. They occur on Volcan de Barba mixed with *Gaultheria Oerstediana*, *Gunnera insignis* (the most northern representative of the genus) and a *Calceolaria*. The sides of the crater are clothed with thick bushes of *Psidium costaricense*, *Myrtus Oerstedii*, *Myrsine rapanea* and several others. — There is no trace of vegetation on the upper part of Volcan de Reventado. The crater lake, however, is surrounded by compact rows of oaks supporting various epiphytic plants such as *Odontoglossum Oerstedii*. Here also grow *Senecio Oerstedianus*, *Hieracium irasuense*, as well, as species of *Vaccinium*, *Viola* and *Geranium*. — On the higher parts of Volcan Irazu, all arboreous vegetation ceases. The trachyte covered with vegetable mould is thickly carpeted with *Lupinus* and *Alchemilla*. At 11,000 feet in volcanic sand are found tufts of *Chionolaena lavandulifolia*, *Castilleja irasuensis*, *Pernettya coriacea*, *Vaccinium densiflorum*, *Sphacele alpina* and two other species, which form thick bushes six to seven feet high clothed with *Usnea* and a leafless, yellow *Viscum*.

According to HEMSLEY, the mountains in western Veraguas, Panama possess a vegetation resembling the Mexican highlands. Species of Alnus and Rubus are found with Fuchsia and Salvia; the brake Pteris aquilinum grows with Lupinus and Ageratum. Oaks and palms are intermingled, while the following genera are represented: Ageratum, Centradenia, Clematis, Conostegia, Freziera, Fuchsia, Galium, Euphorbia, Smilax, Styrax, Salvia, Rondeletia, Rhopala, Equisetum and Lopezia.

*Savanna Formation.* Savannas are found especially on the Pacific coast of Costa Rica. The savannas situated between the coastal and main cordilleras are interspersed with woodland and may be compared to an archipelago of savanna islands in a forest-sea. This character of the landscape extends to the border of Panama, and as far, as the southern end of the Chiriqui cordilleras. The savannas in Panama [1]) exist only on the Pacific side of the Isthmus, where they form a grassy belt sixteen to eighteen miles broad lying between the littoral formation and the mountains. — In Costa Rica the plants of the savannas are, according to TONDUZ: *Curatella americana*, *Byrsonima crassifolia*, *Miconia argentea*, and the grasses in the list from the "Savanes de la Cruz" are species of *Sporobolus*, *Andropogon*, *Trachypogon*, *Paspalum*, *Scleria*, *Cyperus* and *Rhynchospora* [2]).

1) COWELL, J. F.: Explorations in Panama, see Bibliogr. p. 82.

2) TONDUZ, AD.: Herborisations au Costa Rica; see Bibliogr. p. 86.

The ground of the savannas in Panama is clothed with a turf of brilliant green consisting of *Scleria nutans, Rhynchospora comata, Paspalum distichum, P. irrigatum, Panicum maximum,* Eragrostis ciliaris, and Papilionaceae, Polygalaceae, Gentianaceae, Violaceae. Groups of trees and bushes rise here and there. The trees belong, according to HEMSLEY, to such orders as Myrtaceae, Melastomaceae, Chrysobalanaceae, Papilionaceae, Verbenaceae, Compositae, Dilleniaceae, Anonaceae, Malpighiaceae, Acanthaceae overspread by plants of the Convolvulaceae, Aristolochiaceae, *Apocynaceae and climbing plants of other natural orders, and such ferns as* Pteris aquilinum, Schizaea occidentalis. The chumicales, or groves of sand-paper trees, Curatella americana, form curious features of the landscape.

POTREROS FORMATION. The potreros in Costa Rica, according to RIDGWAY, are covered with trees supporting vines and epiphytes. Near the streams tree ferns are common. The high potrero *(9,000 feet) at the base of the ash cone of Turrialba is a park-like* savanna with groves of fine trees dotted over the undulating grass land and bearing epiphytic ferns, bromeliads and orchids. POLAKOWSKY mentions the plants of the potreros as Alternanthera achyrantha, Dalea alopecuroides Hyptis pectinata, Marsypianthes hyptoides, Mimosa pudica, M. invisa, Muhlenbergia tenella, Polygala paniculata and species of Panicum and Paspalum.

Catingas Formation. POLAKOWSKY speaks of the Catingas of Costa Rica using that word in the Brazilian sense, where this formation typically exists. The light forests (Catingas), which exhibit the phenomenon of the fall of the leaf and stand during the hottest, driest season stripped of all their foliage remind the traveller of the northern forests in their leafless winter condition. With the first rains, the trees become clothed with green foliage. These stand in the Costa Rican region interspersed with the open forest found rarely away from the Pacific side, and savannas[1]) in the central and western parts of Nicaragua and in Guanacaste in Costa Rica.

## Chapter VII. North American Tropic Zone: West Indian Section.

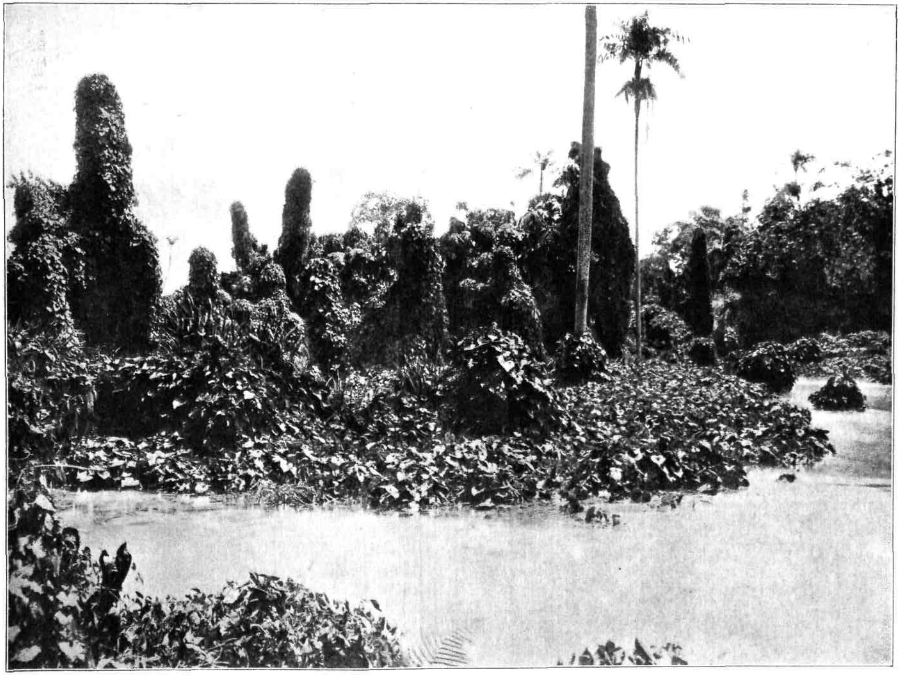
The floristic section of the West Indian Islands includes three distinct regions, viz.: the Antillean, the Bahaman and the Bermudan. Each of these regions is characterized by a flora which owes its character to climatic, historic and edaphic factors. The high mountain chains in the Antillean region with numerous freshwater rivers and streams give to its flora a diversified character not possessed by the flora of the Bahama and Bermuda islands, which are generally low, calcareous and without running streams. The flora of the Greater Antilles possesses in many places the tropic luxuriance of a rain forest, while in the Bahamas, the plants are more or less xerophytic and the arborescent vegetation in the nature of chaparral, rather than associated together into a true forest. Besides the flora of the Bahama, and especially the Bermuda islands, is derivative, while that of the Antillean islands is much older and represents the remnants of a flora which was coincident with the former Antillean continent[2]).

### 1. Antillean Region.

This includes the islands of Cuba, Jamaica, Santo Domingo, Puerto Rico and the Virgin islands. The Lesser Antilles are excluded because

1) NIEDERLEIN, G.: The Republic Costa Rica p. 34; see Bibliogr. p. 85.

2) See ante, pages 122, 305—310; Cfr. JOHNSTON, JOHN R.: Flora of the Islands of Margarita and Coche, Venezuela. Proc. Boston Soc. Nat. Hist. XXXIV: 163—312. 1909.



Vegetation in Roaring River Bed, Jamaica.
River Bank Formation.
Reproduced by permission of the Philadelphia Museum.

their flora is of different origin and much younger in point of time than that of the Greater Antillean chain. For convenience, and because the division is a natural one, the flora of the Antillean Region has been divided into four districts, as follows: Cuban, Jamaican, Santo Domingan and Puerto Rican districts. Each of these will be considered separately, although they possess many phytogeographic features in common, as for example, a similar strand and mangrove vegetation.

## A. Cuban District.

This phytogeographic district comprises the Island of Cuba, the Isle of Pines and outlying islands and keys. It is difficult in the absence of exact data to give an account of the plant formations of this district; but a general sketch, which will give the salient features of its flora, is of importance.

The flora of Cuba is noted for a large number of endemic types and also for the striking character of those types, their occurrence and their distribution. A comparison with the flora of Florida shows a great difference, while a comparison with Central and South America shows it to be almost identic with them in general character; and this is probably due to two facts: (1) Cuba and the other Greater Antilles were at one time connected intimately with Central and South America [1]), and their floras practically identic (see map ante p. 172); (2) The Gulf Stream washing the shores of northern South America is deflected from the coast of Central America into the Caribean Sea, carrying all tropic seeds over into the West Indies. Cuba's great coast line and its proximity to the stream, a part of which flows along the south coast and a part making a circuit of the Gulf of Mexico, striking the north coast of Cuba, would greatly favor the reception of such seeds. — The distribution of the flora over the Island is very interesting. The many different kinds of soil, the altitude, the proximity to the sea, all combine to make a diversified flora.

Presumably the Mangrove Formation in Cuba is similar to those swamps that occur in the other West India Islands where *Rhizophora mangle*, *Avicennia nitida*, *Conocarpus erectus* and *Laguncularia racemosa* are prominent. The Isle of Pines is completely surrounded by mangrove vegetation. — The Dune Formation includes the sandy beaches and sand dunes found in many parts of the island.

In general, the flora of such sandy places has much in common with similar locations in other parts of the Antillean archipelago. The plants of the sand dunes in Cuba are: Suriana maritima, Sesuvium portulacastrum, Borrichia arborescens, Ipomoea pes-caprae, Euphorbia buxifolia, Ximenia americana, Maytenus buxifolia, Tephrosia cinerea, Verbesina encelioides, Justicia (Adhatoda) origanoides, etc. The sandy soil or sandy flats are marked by the presence of Sida cordifolia, Corchorus hirsutus, Malpighia coccigera, Myginda rhacoma, M. ilicifolia and Pisonia discolor.

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1) GUPPY, R. J. LECHMERE: The geological Connexion of the Caribean Regions. Trans. Canadian Institute VIII: 373—391. 1908—1909.

Where the rocky strata reach the shore, the waves have worn them into their present irregular Sea Cliff Formation. Upon such rocky shores in southern Cuba grow Canavalia obtusifolia, Opuntia tuna, Rachicallis rupestris, Tournefortia gnaphalodes, Phyllanthus epiphyllanthus, Ayenia pusilla, Bursera angustata, Erythroxylum brevipes, Malpighia urens var. lanceolata, Picrodendron arboreum, Ceanothus reclinata, Gliricidia platycarpa, Sophora tomentosa, Ateleia apetala, Bourreria montana, Alternanthera muscoides.

The sterility of the river bottoms and river deltas south of the Sierra Maestra of Cuba is a marked feature of the country. With the exception of species of *Plumiera* and a few other species such areas are without trees. A rank growth of shrubs gives the whole river bottom a characteristic appearance not unlike "the scrub" of the Bahama islands, according to TAYLOR [1]).

Along the streams in the Isle of Pines, according to ROWLEE [2]), and elsewhere in Cuba, the vegetation shows in the River Bank Formation the least xerophytic tendency and closely approaches the conditions found in humid tropic regions. The trees are mostly large. Palms abound, also shrubs of many kinds. Several plants of the banana family occur here together with many ferns and orchids.

The gorges of the south side of the Sierra Maestra of Cuba, according to TAYLOR are profusely covered with vegetation. Here occur Campyloneuron angustifolium, C. phyllidītis, C. latum, Polypodium polypodioides (= P. incanum), P. plumula, Philodendron lacerum, Renealmia occidentalis, Epidendrum cochleatum, Peperomia acuminata, P. obtusifolia, P. rotundifolia, P. scandens, Boehmeria littoralis, Pilea nudicaulis, P. microphylla, Rojania hastata, Picramnia pentandra, Pavonia typhalaea, Gilibertia arborea, Wallenia laurifolia, Asclepias nivea, Solanum triste, Hamelia lutea, Psychotria lasiopthalma, Chiococca racemosa, Dicliptera assurgens, Adenostemma Berteri. The abundance of water in these gorges in contrast to the slopes produces a luxuriant flora and through the decay of generations of these plants a rich damp soil has been formed.

Mud swamps are found at several places in the island of Cuba, as at Cienfuegos [3]). Little is known about them; except that here grows the large fern, usually in pure association, *Acrostichum aureum*. No information is available as to the association of plants in the rivers and freshwater lagoons of Cuba, but the following aquatic plants of southern Cuba presumably are important elements in such associations: *Nasturtium officinale*, *Nymphaea ampla* var. *pulchella*, *Jussiaea repens*, *Utricularia spirandra*, *Sagittaria intermedia*, *Potamogeton fluitans*, *Naias guadalupensis* and *Marsilia polycarpa*.

*Savanna Formation.* The savannas are wooded grass lands, grading into upland woods on the one hand, and into what are called "maniguas," and prairies with scattered clumps of bushes, on the other, and varying with the soil, as to whether, it is red, gravelly, or black. According to ROWLEE, the savannas in the Isle of Pines may be wet, or dry. The dry savannas extend to the uplands and have steadily increased in size as the natives have burned them over to improve the pasturage. Besides sedges and grasses,

1) Torreya VII: 53.

2) ROWLEE, W. W.: See Bibliogr. p. 91 and Ecological Conditions of Plant Growth in the Isle of Pines. Science new ser. XVII: 461.

3) COMBS, ROBERT: District of Cienfuegos, see Bibliography p. 88.

there are many other herbaceous plants, especially species of Leguminosae. These plants make a dense sward. Scattered everywhere over the savannas are arborescent palms, mostly of the palmetto type.

The following are some of the plants which according to COMBS are inhabitants of the savannas with underlying red soil: Davilla rugosa, Polygala angustifolia, Wissadula periplocifolia, Guazuma ulmifolia, Luhea speciosa, Crotalaria pumila, Brya ebenus, Belairia mucronata, Poeppigia procera, Cassia chrysocarpa, Mimosa pudica, Lysiloma latisiliqua, Calycorectes protractus, Cuphea Parsonsia, Casearia spinescens, Piriqueta cistoides, Turnera pumilea, Passiflora ciliata, Rondeletia trifolia, Genipa caruto, Vernonia menthaefolia, Chrysanthellum procumbens, Pectis ciliaris, Jacquinia linearis (along brooklets), Rauwolfia Alphonsiana, R. cubana, Echites rosea, Ipomoea tenuissima, Solanum callicarpaefolium, Scoparia dulcis, Buchnera elongata, Vitex ilicifolia, Hyptis gonocephala, and Copernicia hospita.

The fertile savannas on the south shore of Cuba, presumably those with the black soil, are noted for the presence of the following plants, according to COMBS: Clematis dioica, Urena sinuata, Eriodendron anfractuosum, Melochia nodiflora, Triumfetta semitriloba, Corchorus siliquosus, Malpighia urens, Gouania tomentosa, Serjania diversifolia, Spondias purpurea, Crotalaria retusa, Indigofera tinctoria, Centrosema Plumieri, C. virginianum, Clitoria glycinoides, Acacia sarmentosa, Psidium guajava, Eugenia axillaris, Casearia hirta, Passiflora suberosa, Alibertia edulis, Mikania orinocensis, Lucuma mammosa, Tabernaemontana citrifolia, Echites rosea, Asclepias curassavica, Hydrolea spinosa, Ehretia tinifolia, Tournefortia bicolor, Ipomoea umbellata, Solanum verbascifolium, S. jamaicense, Angelonia angustifolia, Gerardia hispidula, Ruellia tuberosa, Curculigo scorzoneraefolia, Oreodoxa regia, with such grasses as, Paspalum paniculatum, Andropogon bicornis, Panicum leucophaeum, Setaria setosa, Sporobolus Jacquemontii, and a fern Anemia adiantifolia. Rhipsalis cassytha is found hanging from palmetto trees.

*Open Forest Formation.* This usually adjoins and grades imperceptibly into the savanna formation. The lee, or south slopes and ridges of the Sierra Maestra along the south shore of Cuba west of Santiago are covered with a dense growth of trees, according to TAYLOR [1]). The lack of undergrowth is very marked and throughout the forest is an unbroken succession of ridges and slopes carpeted with little but dried leaves. The grasses *Arthrostylidium capillifolium*, *Oplismenus hirtellus*, *Pharus latifolius* and *Renealmia occidentalis* are the most common herbaceous species. Entering the woods in the half shade, according to FERNOW [2]) the botanist finds the undergrowth to consist up to 2500 feet of a species of *Calyptranthes*, although the undergrowth is not dense owing to the lack of surface water.

The trees of such forests, never in pure stand, are Ceiba pentandra, Bursera simaruba, Spondias lutea, Cedrela odorata, Swietenia mahagoni, Pithecolobium arboreum (= P. filicifolium), Bocagea virgata, Carpodiptera cubensis, Lysiloma sabicu, Lonchocarpus sericeus, coffee and lemon trees runwild, together with such plants as Tillandsia fasciculata, Vanilla phaeantha, while conifers are absent, except Pinus occidentalis on the driest peaks above 1,800 feet.

The Pine Barren Formation is distributed throughout Cuba, but in what localities is not known. On approaching El Yunque, a mountain near Baracoa at the east end of Cuba, the country becomes densely wooded and the scattered clumps of Oreodoxa regia observed below 2,000 feet are absent. About three miles north of El Yunque is a range of high steep hills forming the watershed between the Duava and Toa rivers. The tops of these hills are occupied

1) Torreya VII: 51.

2) Bulletin American Geographical Society XXXIX: 257—268.

an open pine forest that is sharply marked off according to F. S. EARLE[1] from the surrounding forest areas.

The pineland on the Isle of Pines, according to ROWLEE[2], resembles that of the Gulf coast of the United States. The pine-timber predominates over considerable areas and consists of Pinus caribaea (= cubensis) (see plate VI at page 306), Pinus recurvata, and P. caribaea var. anomala. The pines are best developed on the higher ground and with them are commingled palms, especially on the lower lands.

*Tropic Forest Formation.* The great forest area of Cuba occupies the interior of the eastern end and stretches unbroken a distance of 60 or 70 miles. This forest contains scattered trees of *Swietenia mahagoni*, *Cedrela odorata* and other trees together with vines and bushes which form an impenetrable tangle. The fungi of this forest include an abundance of Polyporaceae and Thelephoraceae; Hydnaceae are rare; the ground-inhabiting Agaricaceae are almost entirely wanting, while the kinds growing on rotten wood are fairly abundant.

The Sierra Maestra watered by the Guama River were almost completely covered by Oxandra (Bocagea) virgata and a species of Calyptranthes. There also grow the Spanish cedar (Cedrela odorata), mahogany (Swietenia Mahagoni) and the ever-present Cecropia peltata and Spondias lutea. A halanophoraceous parasite Scybalium jamaicense grows on the roots of Cassia emarginata at an altitude of 2,100 feet, according to NORMAN TAYLOR[3].

In the Isle of Pines, the trees of this forest are species of *Clusia*, *Ficus* and *Cecropia*, while bromeliads, orchids and aroids grow upon the trees and shrubs. On the rocks among the trees are species of *Plumeria*, *Billbergia*, *Furcraea*, and cacti in great profusion; palms are abundant particularly on the perpendicular faces of the mountains.

On the south shore of Cuba, near Cienfuegos, this type of forest only exists where the rain is sufficient to foster a rich and luxuriant tropic growth. Such a rainfall only occurs on those mountain slopes which face in the direction from which the rain clouds come, that is toward the prevailing moisture containing wind. The vegetation on the north slopes of the Sierra Maestra is watered by abundant rains and consequently the member of species is so great that one is bewildered by the richness of the flora. Filmy ferns, tree-ferns, epiphytic orchids, bromeliads, hepatics and mosses together with many species of the genus *Peperomia* seem to predominate. The lee or protected slopes of such mountains are generally arid and are covered with a xerophytic vegetation.

The atmosphere here is nearly saturated with moisture, an ideal environment for plants of all kinds. Almost every tree is covered with epiphytes, mostly ferns, orchids and Peperomias, while on the ground grow grasses. Such as Oplismenus and Arthrostylidium, the latter often running up into the trees. Of the orchids a little Pleurothallis was the most common. The genus Stelis is also represented together with melastomaceous shrubs and trees confined solely to the wet mountain slopes. The following trees, according to FERNOW[4], grow in these wet woods:

1) EARLE, F. S.: Trip to eastern Cuba: see Bibliogr. p. 88.

2) ROWLEE: Loc. cit. p. 36: Notes on the Antillean Pines with Description of a new Species from the Isle of Pines. Bulletin Torrey Bot. Club XXX: 106.

3) Journal New York Botanical Garden VII: 259; Forestry Quarterly IV: 270—273.

4) The High Sierra Maestra, Forestry Quarterly IV: 239—269.

Tropic Forest Formation

in gorge Rio Cobre River (Bog Walk), Jamaica. Dead Tree loaded with epiphytic orchids and bromeliads.

Ochroma lagopus, Paritium elatum (= Hibiscus elatus), Rheedia aristata (rare), Calophyllum calaba, Bocagea laurifolia, Genipa americana, Guarea trichilioides, Styrax obtusifolium, Chrysophyllum glabrum.

## B. Jamaican District.

Owing to the topographic configuration of this island with elevated mountains, plateaus, valleys, rivers and plains the flora although tropic in character is of the most varied constitution. The prevailing tropic vegetation of Jamaica is distinctly related to that of the Central and South American mainland, as is shown in the great profusion and variety of Melastomaceae, Myrtaceae and Cinchonaceae and the total absence of Cupuliferae and Abietineae. Although the flora is well known, botanically speaking, no authoritative systematic work has ever been published and there is no satisfactory phytogeographic sketch extant. This the present sketch in part attempts to supply.

The Mangrove Formation exists in a considerable number of localities along the coast line of Jamaica notably according to my observations in Kingston Bay, Montego Bay and the harbor of Port Antonio. Its constitution is similar to that in other parts of the tropics. At the marshy edges of a mangrove swamp, I found *Mariscus rufus* and *Fimbristylis spadicea.* — The constitution of the Dune Formation is essentially similar to that on other tropic sand dunes. *Ipomoea pes-caprae* according to my observations is the character plant of low beaches. Recently BRITTON has discovered on the dunes west of Black River, a tall palm (*Thrinax*) known locally as bay thatch or pimento.

The Sea Cliff Formation exists along the entire coast line of Jamaica, except where broken by reentrant bays, or by sandy beaches.

According to my observations[1]), the rocks near Port Antonio, projecting over the sea and in storms wet by the spray (that is, tossed up from beneath), support Wedelia carnosa, Coccoloba uvifera, Ruellia tuberosa, Crotalaria incana and Plumeria sp. Hanging over the rocks and lying prostrate on the ground is Borrichia arborescens. — On the ocean cliffs at Runaway Bay grows Rhachicallis maritima a shrub known only in Jamaica at this point. This formation is well represented at Lover's Leap, a precipice at the coastal end of the Santa Cruz Mountains in southwestern Jamaica. Here in the dry soil was obtained one of the larger Jamaican cacti, a species of the genus Pilocereus. The columnar branched plant fifteen feet high was found on the cliffs at 1,600 feet altitude. This being a region of low rainfall the cacti form extensive groves and the plants are adapted to dry conditions notably the rare, wand-like shrub Lasiocroton macrophyllus. In the woods of the Santa Cruz Mountains Dr. BRITTON collected Bauhinia porrecta and the rare Peltostigma of the rue family. The rocky woods at Negril Point yielded many rare species, including the "wild sago" (Zamia) and the fine spider lily (Hymenocallis).

*Savanna* and *Chaparral-Formation.* In all probability this formation was a prominent one in the southwestern part of the island before the land was devoted to agriculture and grazing. Much of the best pasture land is found in the St. Catherine, Clarendon, Manchester and St. Elizabeth parishes and presumably the ancient grassy savannas were early devoted to the rearing of

1) HARSHBERGER, JOHN W.: Strand Flora of Great Inagua etc.: see Bibliogr. p. 89.

cattle, the country having every appearance of having been grassland for a long time. —

Liguanea Plain and the Salt Pond District are covered with chaparral, which owes its presence to the much diminished rainfall on the south side of the island as compared with the almost daily rains on the north side. This meteorologic fact is reflected in the vegetation. The country is covered with the mesquite, *Prosopis juliflora*, logwood, *Haematoxylon campechianum*, *Yucca aloifolia*, *Pithecolobium unguis-cati*, *Inga vera*, *I. ingoides*, *Acacia farnesiana* and other leguminous trees and shrubs, while such cacti, as *Opuntia tuna*, *O. spinosissima*, species of *Cereus* abound, together with *Bromelia pinguin* and other xerophytic types of plants.

Limestone Sinks (Cockpit) Formation. The vegetation of the cockpits on account of the inaccessibility of the country has never been investigated thoroughly, and we know little about the associations of plants there. The cockpits, which are west of the Clarendon ridges, vary in depth from shallow, circular, basin-like depressions surrounded by low mamillary hills to steep-side sinks often 500 feet deep. These are developed in the upper part of white limestone. Below is another white limestone, also soluble, but less pervious than the former, and below this again, nodular limestone, clays and conglomerates of the older insoluble and impervious strata which check the downward course of the lime-charged waters and force them to take a horizontal direction. When the bottoms of the cockpits reach the more resisting limestone of the second group, their perimeters begin to expand and round or oval valleys are formed known in Jamaica as light-holes. The flora of these sinks is peculiar and is still open to investigation.

In the Great Morass of Westmoreland, according to BRITTON [1]), we have a swamp of large extent similar in some features to the Everglades of Florida. The rare tree *Crudia Schreberi* (= *C. spicata*) grows here, as well, as the marsh cabbage palm *Oreodoxa* and a veritable forest of the long thatch palm *Geonoma Swartzii*. —

The River Bank Formation is typically developed along the numerous streams in Jamaica, but as it insensibly merges into that of the tropic rain forest, it will be best to refer to it again under that head. Roaring River where it passes under the road from St. Ann's Bay to Ocho Rios is a series of low waterfalls separated by nearly level stretches which present the curious aspect of many large trees (*Bucida buceras*, *Grias cauliflora*) growing directly in the water. Their seeds germinate in the calcareous travertine, or tufa, deposited in the level stretches from the water. (See plate XVI to page 672.)

Tropic Forest Formation. This is typically developed on the north side of the island and on the slopes and the summits of mountains where the rainfall is sufficient to stimulate the growth of a rich and luxuriant vegetation. The whole eastern part of the island about the John Crow Mountains is one of very heavy rainfall and the vegetation is wonderfully varied and beautiful. Ferns according to CAMPBELL [2]) abound and in some places thickets of beautiful

1) Journal New York Botanical Garden IX: 85.

2) CAMPBELL, D. H.: Botanical Aspects of Jamaica: see Bibliogr. p. 88; JOHNSON, D. S.: A botanic Expedition to Jamaica. Johns Hopkins University Circular; new ser. 1907: 21.

palms, *Euterpe oleracea*, form a striking feature of the forest. These palms with the tree ferns, large aroids and epiphytic bromeliads give a thoroughly tropic aspect to the vegetation. There are numerous epiphytic orchids and a great variety of species of *Heliconia*, *Hedychium*, *Canna* and tropic liverworts, of the genera *Dendroceros*, *Symphyogyna* and *Monoclea*. In this tropic forest generally, according to my observations, the botanist meets with several species of *Philodendron* climbing high up the trunks of trees, or clambering over rocks. *Syngonium* is also abundant and species of *Anthurium*, *Dieffenbachia*, *Peperomia*, and other genera abound in the more moist situations. Innumerable lianes festoon and smother the forest trees. Some of these are leguminous climbers, others belong to the natural orders Convolvulaceae, Vitaceae, Acanthaceae, and Apocynaceae. The ferns comprise all the tropic types, according to CAMPBELL, the Hymenophyllaceae alone being represented by some fifty species. The Cyatheaceae include the tree ferns (see plate XVIII), *Cyathea*, *Alsophila*, *Hemitelia*, while the order Marattiaceae is represented by *Marattia alata*, *Danaea alata*, *D. elliptica* and *D. nodosa*. The fern order Schizaeaceae comprise '*Schizaea elegans*, *Lygodium volubile*, *L. venustum*, *Ancimia aurita*, *A. hirta*, *A. adiantifolia* and others. *Gleichenia pubescens*, *G. dichotoma*, *G. pectinata* are common and conspicuous ferns. The bromeliads (*Aechmea*, *Caraguata*, *Tillandsia*) occur in nearly all parts of the island and form an important factor in the rich epiphytic flora. One of the most characteristic sights is a large cotton tree, *Ceiba pentandra* (= *Eriodendron anfractuosum*) with its great horizontal branches covered with epiphytes conspicuos among which are orchids, *Cereus triangularis*, *Rhipsalis cassytha*, many Tillandsias and other bromeliaceous plants (see plate XVII, to page 677, Bog Walk.) Sixty species of orchids are found in the island, the more interesting epiphytic types in this rain forest formation. There are pretty species of *Epidendrum*, a brilliant crimson orchid *Broughtonia sanguinea* and such terrestrial orchids as *Bletia florida*, *B. verecunda*.

The most detailed account of the mountain forests of eastern Jamaica we owe to FORREST SHREVE (1906, see Bibliogr.) who penetrated them in a large valley drained by a branch of Spanish River lying between Vinegar Hill and John Crow Peak (6,000 feet), the most westerly high peak of the Blue Mountain Range. Over the river the trees form a closed arch and here such trees as Symphonia globulifera, Calophyllum calaba reach a height of 100 feet. The long thatch palm Geonoma Swartzii, Heliconia bihai, species of Canna, Philodendron and numerous shrubby and arborescent Rubiaceae and Melastomaceae are present. The epiphytic forms are exceedingly rich: Pilea radicans covers the limbs of the shrubs to a height of 20 feet; Trichomanes pyxidiferum and T. muscoides clothe the lower portions of many trunks and Polypodium phyllitidis and P. serpens are larger climbing ferns. The rich terrestrial herbaceous vegetation consists of ferns, species of Pilea and Peperomia, as well as several orchids. Scarcely a leaf of the undergrowth is without its epiphytic Hepaticae (which have been studied systematically by Prof. EVANS of Yale University, Cfr. Bibliography) and some large fronds of Danaea and Acrostichum are completely covered. Among the interesting ferns in this forest are Vittaria lineata, V. remota, Aspidium Fadyenii, Danaea jamaicensis, Davallia cicutarioides, Gymnopteris aliena and Rhipidopteris peltata. Hanging from the trees is Lycopodium taxifolium and nearby is the rare Psilotum complanatum. Among the epiphytic orchids occur Liparis elata, Masde-

vallia fenestrata, Epidendrum fragrans, E. bletioides, E. polybulbon which climbs over the limbs of trees with Peperomia cordifolia, as well, as Comparettia falcata and Pleurothallis tribuloides. The vegetation of the valley slopes consists of the shrubs Cephaëlis punicea (= C. elata), Hoffmannia pedunculata, Clidemia (Sagraea) plumosa, the trailing Schradera cephalotes and the root parasite Scybalium jamaicense. Scattered colonies of Burmannia sp. are found together with such ferns as Marattia alata, Lygodium volubile, Gleichenia furcata, Cyathea arborea (see plate XVIII), as well as species of Botrychium, Davallia, Danaea, Trichomanes, Hymenophyllum, Lomaria and Elaphoglossum. Among the trees may be seen species characteristic of higher altitudes as Podocarpus Urbanii, Vaccinium meridionale, Alchornea latifolia, Guarea trichilioides and Laplacea haematoxylon, a plant with splendid, white, rose-like flowers.

In the forest at over 2,200 feet altitude near Bluefields grow Columnea, a vine of the Gesneriaceae and three species of the bromeliaceous genus, Hohenbergia. The forest of Dolphin Head in western Jamaica consists of a variety of trees and shrubs such as the elegant white flowered vine Blakeo, the nickel-tree (Ormosia), a tall forest tree, as is also Hernandia with its curious pouch-like, translucent fruits. On the hills and mountains of St. Ann's Parish occur Thrinax tessellata and Podocarpus Purdicanus, a large forest tree. (See colored map.)

*Mountain Summit Formation.* Above the tropic rain forest, the occurrence of sphagnum mosses, as well, as *Lycopodium clavatum*, *L. complanatum*, *Fragaria vesca*, *Rubus alpinus*, *R. jamaicensis*, *Ranunculus repens*, *R. parviflorus*, mixed species of *Begonia*, *Gleichenia* and other tropic types show the meeting of mountain and northern types with the tropic lowland flora.

The trees at the summit of Blue Mountain Peak are somewhat dwarfed. Among the most characteristic trees of the higher altitudes is *Vaccinium meridionale*, associated with *Podocarpus coriaceus*. Tree ferns (in three species) also abound, but are not so fine as those somewhat lower down. The fern flora of the mountain summit consists of *Asplenium Harrisii*, *A. Fawcettii*, and a fern allied to *Cystopteris fragilis* (which may be the long lost *Cystopteris jamaicensis*) and a *Nephrodium* are among the many rarities growing there[1]. The summit of Sir John Peak (6,100 feet) is clothed with bushes of *Vaccinium* sp., *Clethra Alexandri* covered with mistletoe and a large new grass *Danthonia Shrevei* growing in dense tufts and covering extended areas almost to the exclusion of other vegetation.

## C. Santo Domingan District.

Santo Domingo excels Puerto Rico, Cuba and Jamaica in altitude, diversity of configuration, picturesque aspect and natural fertility. It is continental in its topographic make-up, consisting of lofty forest-covered peaks and deep valleys threaded by streams of limpid water. There are many central valley plains in the island. The largest of these, lying between the Monte Christi Range and the Cordillera Cibao, extends from the sea at the Haitian border to Samana Bay. The western portion watered by the Yaqui is an arid region covered by chaparral, where arborescent opuntias and cereuses abound. The windward area, or eastern division, watered by the Yuna has a mesophytic

1) UNDERWOOD, L. M.: Account of Explorations, see Bibliogr. p. 92.

tropic flora. The terraced Caribean coast supports a belt of forest averaging twelve miles in width. The tension line between coastal forest and inland prairie is park-like in aspect and forms savannas, which are carpeted by green grass and dotted with clumps of trees. — These areas of course vary with the configuration of the country. In general the lee slopes of mountains and valleys are arid, or dry, being cut off from the moisture containing prevailing winds; while the windward slopes are usually clothed with rich and luxuriant tropic vegetation.

The country has never been explored thoroughly for botanic purposes and many interesting plants remain to reward the toil of the explorer. In the absence of satisfactory information, the following arrangement of formations has been adopted tentatively.

The Mangrove Formation, according to my observations[1]), exists typically in all of the large harbors, or bays of the island of which there are many beautiful ones. The three trees concerned in forming the mangrove swamp are *Rhizophora mangle*, *Avicennia nitida* and *Laguncularia racemosa*. — Along the shore the usual strand flora is found; conspicuous among the plants here being *Coccoloba uvifera*, *Ipomoea pes-caprae*, *Hymenocallis* and many other seaside plants. Back of the dunes comes a belt of low woodland, which gradually merges into the vegetation of the low hills. These low woods are characterized by species of *Clusia*, *Ficus*, *Haematoxylon*. Extensive salt lakes, or ponds, are found in the southwestern parts of the island.

In the Republic of Haiti, as well as in that of Santo Domingo, there are many arid plains which owe their origin to their location on the leeward side of mountains. Here we find a xerophytic flora composed of *Opuntia tuna*, *O. spinosissima*, species of *Cereus*, *Nopalea*, *Mamillaria*, *Melocactus*, *Peireskia aculeata*, together with species of *Agave*.

The Chaparral Formation exists in many places and the component vegetation consists of *Acacia farnesiana*, *A. sphaerocephala*, *Prosopis juliflora*, *Yucca aloifolia* and other xerophytic shrubs and herbaceous plants. This formation grades imperceptibly into the formation of arid plains. It exists about Azua and other places on the south coast of the island. — The Savanna Formation forms green covering of the open park-like areas and consists of species of the following genera of grasses as of the chief components of savanna land: *Paspalum*, *Chloris*, *Panicum*, *Andropogon* and *Eragrostis*[2]).

The savanna at San Michel in north central Haiti is fringed by a xerophytic strip which merges into the pinelands of the mountain foot hills covered with Pinus occidentalis, a palm Thrinax sp. and a species of Agave, according to NASH[3]). Low shrubs characterize this savanna and a species of Duranta occurs near the banks of dry streams that carry water in wet weather. On the plain of Gonaives the vegetation consists of small trees mingled with which are numerous

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1) In the harbor of Cape Haitien, Gonaives Bay, Aux Cayes harbor and harbor of Jacmel in 1901. NASH, GEO. V.: An new Grass Endemic to Jamaica. Torreya IX: 209.

2) HARSHBERGER, J. W.: Flora of Santo Domingo 1901: see Bibliogr. p. 89.

3) Journal New York Botanical Garden VII: 182.

shrubs supporting great masses of Tillandsia usneoides, Cacti are common, such as Opuntia Dillenii, columnar species of Cereus, Pilocereus forming the characteristic feature of the landscape.

The savanna in the Valle Nuevo in Santo Domingo (2270 m) is dotted over with trees of Pinus occidentalis, on the stems of which grows, according to Urban, the loranthaceous parasite Dendropemon pycnophyllum with fine rose-colored flowers and the ground is covered with such grasses as Agrostis perennans, Danthonia domingensis, Eatonia (Sphenopholis) obtusata and Trisetum toluccence.

*Tropic Forest Formation.* This consists in the mountains near Barahona of a forest rich in mahogany *Swietenia mahagoni*, lignum-vitae *Guaiacum officinale*, fustic *Maclura* (*Chlorophora*) *tinctoria*, satinwood *Zanthoxylum flavum* and lancewood. At 2,900 feet the mahogany disappears and at 3,590 feet the West Indian cedar, *Cedrela odorata* is a dominant forest tree. At a height of 2,000 feet on the north coast, tree ferns begin to make their appearance, and a few scattering filmy ferns, but at an elevation of 3,500 feet, according to Nash [1]), tree ferns and ferns in general become plentiful.

At this elevation, the mountains are covered with clouds in the afternoon and everything is dripping with moisture, the home of filmy ferns, hepatics and many mosses. The larger trees are draped with lianes and their limbs support a rich and varied epiphytic flora of ferns, cacti, bromeliads and orchids; while parasites of the genera Phoradendron and Dendrophthora occur on many of the forest trees. Along the roadside through a lowland tropic forest back of the city of Cape Haitien, I noticed in 1901 [2]), Palicourea pavetta, Salvia micrantha, Lepidium virginicum, Leonurus sibiricus, Sida acuta, Hamelia patens, Tephrosia purpurea, Spermacoce laevis, Achyranthes aspera var. obtusifolia, Centrosema virginianum, Rauwolfia canescens, Solanum aculeatissimum, Hibiscus Boryanus, H. vitifolius, Vinca rosea, Parthenium hysterophorum and the cosmopolitan Argemone mexicana.

At definite elevations on the mountain slopes in Santo Domingo, as at Marmalade (3,000 feet), the tropic forest is replaced by a Coniferous Forest Formation. On account of the open growth of the trees, the appearance of this pine forest is similar to the pineries of the southern United States, but here the pines cover the mountain sides. The undergrowth is extremely dense, consisting of small trees and shrubs and such herbs in the Valley of Constanza (1170 m) as Ascyrum hypericoides, Oxalis Eggersii, Desmodium ciliare, Rubus domingensis, Aster exilis, Hieracium carolinianum, H. venosum, Pteris (Pteridium) aquilina, and as parasites on the pines Dendropemon parvifolius and D. Constantiae. Conspicuous among these are plants of the orders Melastomaceae and Compositae, a species of Agave and many others.

*Mountain Summit Formation.* The loftiest peak in the island is Mount Loma Tina (10,300 feet), being situated to the south of the axial line of mountains, northwest of the city of San Domingo. The highest eminence of the main ridge is Pico del Valle, so called, because it is constantly enveloped in silvery clouds. This rises to 9,700 feet, while nearby are many mountains, 8,000 feet, or more in altitude. Up to four thousand feet, pines (*Pinus occidentalis*) are found; further up, as the precipitation increases, are beautiful leafy woods: while on the summits are dense thickets of ferns. According to the observations of Baron H. EGGERS [3]) the vegetation on the summit of

1) NASH, G. V.: Report on Exploration in Haiti; 1903: see Bibliogr. p. 90.

2) HARSHBERGER, J. W.: Strand Flora of Great Inagua, 1903: see Bibliogr. p. 89.

3) EGGERS, H: Excursion into the unknown parts of Santo Domingo Nature XXXVII: 545; see other papers in Bibliogr. p. 89; for other details, see URBAN, IGN.: Zur Hochgebirgsflora von Sto. Domingo. Symbolae Antillanae VI: 280—292.

**Cyathea arborea** Smith (tree fern),
a Group on a Jamaican hillside. This fern which shuns the shade, ranges to 2,500 feet (760 m).
Reproduced by permission of the Philadelphia Museum.

Pico del Valle is three to four feet high (1—2 m), consisting of shrubs such as *Lyonia heptamera*, *Garrya Fadyenii*, while here are found *Peperomia reflexa*, *Pilea alpina*, and the ferns *Vittaria lineata*, *Polypodium angustifolium*, *Elaphoglossum Eggersii*, *E. leptophyllum*, *Asplenium monanthes*, *Lepicystis murorum*, mosses and lichens. The other mountains peaks of which there are many in the island are veritable terra incognita, to reach which the botanist is compelled to slash his way through thickets of ferns, lianes and shrubs often so dense that he must crawl on hands and knees through a tunnel cut by himself, and blinded by spores at every step.

## D. Puerto Rican District.

The islands of Puerto Rico, Culebra, Crab, St. Thomas, St. John, Tortola, Virgin Gorda, Anegada and the adjoining keys together with St. Croix are phytogeographically included in this district. Geographically St. Croix is separated from the other islands by a sea passage, 2,452 fathoms deep; whereas the greatest depth of sea between Puerto Rico and the other islands mentioned does not exceed 23 fathoms and that in the Virgin Passage (see ante p. 124). These islands are all mountainous, projecting above the water as submerged peaks, which they really are. They are very rugged, due to the encroachment of the sea which has formed cliffs, detached stacks and skerries, with winding channels of blue water, like land-locked lakes between the islands. The smaller islands are marked by stretches of coral and shell-sand overgrown with seaside grapes, cactus — a large prickly pear. St. Croix has a high, sharp configuration with deep cliffs near the shore and many low hills in the interior all covered with beautiful vegetation. Two areas are distinguished: the Puerto Rican Territory and the Virgin Island Territory.

### a) Puerto Rican Territory.

This territory comprises the island of Puerto Rico, Culebra and Crab Island.

Puerto Rico, which is rectangular in shape, possesses a central mountain chain known as the Cayey range extending unbroken from end to end of the island with the Luquillo Range, parallel to it on the south (see ante p. 124). Between the two ranges (2,500 feet) lies a mountainous valley full of sharp ridges, detached peaks and deep ravines, with no level land except a few narrow alluvial valleys. Along either coast, extending from the foothills of the mountains to the sea, stretch beautiful plains, gently sloping to the shore and reaching in width at some points on the south side to five miles and on the north side to three miles.

Very little is known concerning the plant formations of Puerto Rico except the tropic forest formation, and consequently no description of them can be given, except for several which have recently been studied. The following account summarizes our knowledge of the phytogeography of the island.

*Coast Formations.* Our information concerning the marine algae of Puerto Rico is due to the work of Dr. F. HAUCK[1]). The cays and inlets of the island are frequently bordered by mangrove vegetation. Presumably the same plants enter this formation as in other parts of the American tropics. — Presumably the Dune, River Bank, Salt Marsh, Swamp, Savanna and Arid Plain formations exist on this island, as in Santo Domingo and Cuba, because Puerto Rico has a similar topographic configuration. The Pine Formation, however, is absent.

*Chaparral Formation.* The chaparral formation occupies the foothills between the southern front of the central mountains and the southern coast, a region which is comparatively arid. The wide playas and stream valleys of this country were once covered with large trees, a few scattered examples of which have been preserved, with the clearing of the land for sugar culture. The flora is markedly different from the mountain region, although there are a few species of trees in common. Low, shrubby, thorny leguminous trees (species of *Acacia*, etc.) covered by Spanish mosses (*Tillandsia*) largely compose the vegetation. In the dry season, the landscape has a brownish color in contrast to the bright greens of the mountain forests. This formation is found, especially well developed on the coast hills between Ponce and Yauco.

In this country, it is accompanied by a thick undergrowth of grass, approaching the condition of a savanna. The limestone summits of the hills, or cerros, west of Yauco are covered by a remarkable growth of chaparral, including a little fan palm Thrinax Ponceana, the Llume palm Aëria attenuata, arborescent cacti, accompanied by thorny trees, the whole draped by Tillandsia[2]). — This formation occurs on the Island of Culebra which, as the altitude of the hills is not sufficient to condense the moisture as rain, is a dry island. Its forest is low and not very dense consisting of guayanilla (Bucida buceras), lignum vitae (Guajacum sanctum) as the largest trees, while cactuses abound in ten species of the genera Cereus, Pilocereus, Mammillaria, Nopalea, Opuntia and a palm (Coccothrinax) and giant century plant (Agave) are found.

*Tropic Forest Formation.* The composition of this forest varies from quebrado[3]) to quebrado and the trees of south and west slopes present distinct differences from those of east and north exposures. But to a large extent the distribution of species is more or less an accident. Trees have grown wherever the many means of distribution have dropped the seeds and where they have found conditions suitable to their needs. It is rare to find trees of the same species in considerable numbers together, except perhaps a palm (*Acrista monticola* Cook) which is more or less gregarious in habit. Here and there single trees or little groups of trees found only in one spot are seen, as for example the mago, *Hernandia sonora.* On the whole, then, the forest growth of the island is far from uniform, although the causes which have brought about its local differentiation are for the most part not of a kind to afford a basis for classification into types.

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1) HAUCK, F.: Meeresalgen von Puerto Rico: see Bibliogr. p. 89.

2) Forest Conditions of Puerto Rico. The Forester V: 234. October 1899.

3) Quebrado = ravine, gorge.

Much of the mountain area is occupied by cultivated crops of coffee, tobacco, fruit trees, shrubs etc., broken by fields of tall Para and Guinea grasses. There are many large cultivated shrubs and bushes which grow here, and hence it is that some of these mountainous portions of the island have, although under cultivation, the aspect of thick primeval forests. Such wooded lands are often coffee plantations [1]).

The original forest has been preserved upon the slopes and summit of El Yunque, the highest peak of the island (3,300 or 3,790 feet) [2]). The forests of El Yunque in general consist of a jungle of trees, underbrush and lianas, and are exceedingly wet, the rainfall averaging one hundred and twenty inches per year. The forest resembles in its main features those of the other West India islands, according to EGGERS in a letter to Sir JOSEPH HOOKER, dated 1883 (Nature, London 1884). Here occur several interesting trees, especially a beautiful *Talauma*, a *Hirtella*, and *Coccoloba macrophylla* found up to an elevation of 2,000 feet [3]).

The United States government has established a forest reserve here which has been designated technically the Luquillo Forest Reserve. Specifically, according to the studies of GIFFORD [4]), the sole distinction which can be made within the reserve is the division into low and high mountain forest. First in importance is the forest which grows in the fertile gorges, ravines and coves protected from strong winds and lying between the altitudes of 500 and 2,000 feet. This forest consists of four dominant trees, viz.: tabanuco (Dacryodes hexandra), laurel sabino (Magnolia splendens), ausubo (Sideroxylon mastichodendron) and guaraguao (Guarea trichilioides). Of these the ausubo is the rarest, while laurel sabino is not so scarce with guaraguao standing third. The most abundant tree is the tabanuco which grows in patches and groups of almost pure stand and is common on the eastern side of the reserve, reproducing freely. Associated with these species, there is a host of others, such as: Bucida capitata (= Terminalia Hilariana), Andira inermis, Ternstroemia luquillensis. There are also many climbing vines, such as Rourea frutescens, R. glabra and a species of grass, which cuts like a razor. Here and there in this belt are groups of mountain palms which have control of extensive areas. In looking down upon the interior basin from the top of El Yunque, it appears, like a sea of palms with islands of dark-leaved hardwoods here and there. Probably fifty per cent. of this fertile basin is covered with these palms.

Above the 2,000 foot contour line, there is another kind of forest growth. This is a stunted, gnarled, slow-growing vegetation, made up of many species. The limbs are moss covered and the roots in many cases bare. These are the rough mountain tops where the vegetation helps to restrain the floods and hold the soil. — Trees to the number of ca. 85 species of trees according to GIFFORD [5]) and BARTLETT occupy the Luquillo Reserve in Puerto Rico.

## b) Virgin Islands Area.

The islands included in this area, mentioned from east to west, are: St. Thomas, St. John, Tortola, Virgin Gorda, Anegada and, distinct from the

1) COOK, O. F.: Shade in coffee Culture. Bulletin 25. U. S. Division Botany 1901.

2) HILL, R. J.: Forest Conditions of Porto Rico. Bull. 25. U. S. Div. Forestry 1899. (Bibl. p. 89.)

3) The forest Conditions of Puerto Rico. The Forester V: 234.

4) GIFFORD, J. C.: The Luquillo forest Reserve, see Bibliogr. p. 89.

5) GIFFORD: Loc. cit. Appendix pages 35—45.

rest, St. Croix. Looking at the vegetation of St. Croix and the Virgin islands in its generality, and without entering into details, we may consider it to be identic, as a whole, showing the same main features. Our knowledge of the flora of these islands is due to the labors of several botanists[1]).

On the sandy shore and on the dunes consisting of innumerable pieces of broken shells and corals is found a luxuriant flora, which remains green throughout the year, even in dry spells, because of the underground water which filters down from the hills above. The species which inhabit the strip of upper beach form an Ipomoea pes-caprae Association. The vegetation is in general sparse, the patches of plants being separated by bare stretches of sandy beach. Directly behind the upper beach, the botanist finds an association of trees and shrubs which correspond to the Barringtonia Formation in Java. The trees of this Coccoloba-Hippomane Association are *Hippomane mancinella*, *Coccoloba uvifera*, *Chrysobolanus icaco* (more rare), *Thespesia populnea*, *Terminalia catappa* with *Caesalpinia* (*Guilandina*) *bonduc* and *C. bonducella* in the shade of the dominant trees.

The species of the rocky cliffs are mostly shrubs of low growth with thick and coriaceous leaves that are able to resist the force of the wind. The most common plants of such situations, according to BOERGESEN and PAULSEN, are *Zanthoxylum spinifex*, *Erithalis fruticosa*, *Jacquina armillaris*, *Borrichia arborescens* and *Conocarpus erectus* (a mangrove swamp plant here under different edaphic surroundings) and, according to EGGERS, *Plumeria alba*, *Coccoloba punctata*, *Elaeodendron xylocarpum* and such herbaceous species as *Stenotaphrum americanum*, *Paspalum distichum*, *Sesuvium portulacastrum* and *Euphorbia buxifolia*. A tree also characteristic of rocky shores is *Baccharis dioica*, while on the rocky coasts of St. Thomas and St. John occur many succulent plants: *Agave Morrisii*, *Cereus floccosus*, *Opuntia tuna*, *O. humilis* and a species of *Thrinax*.

*Mangrove Formation.* As before mentioned, the mangrove vegetation inhabits the bays and the lagoons along shore, as well, as the salt ponds of the interior. In many situations *Rhizophora mangle* is the sole constituent, forming a dense forest growth with interlacing branches above, where beneath the shade thus found are associated *Herpestis Monniera* and *Acrostichum au-*

1) EGGERS, BARON H. F.: The Flora of St. Croix and the Virgin Islands. Bulletin 13 United States National Museum 1879; BOERGESEN, F. & PAULSEN, OVE: La Végétation des Antilles Danoises. Revue Générale de Botanique Tome XII: 1—108; BOERGESEN, F. & ULDALL, F. P.: Vore Vest indiske Øer. 1900; MILLSPAUGH, CH. F.: Flora of the Island of St. Croix. Field Columbian Museum. Botanical Series Publication 68. Vol. I. No. 7. November 1902; BOERGESEN, F.: An ecological and systematic account of the Caulerpas of the Danish West Indies. Mem. Acad. Roy. Sci. Lett. de Danemark 7me. Ser. Sect. des Sci. A. IV No. 5. 1907; Vegetationen i Dansk Westindien; Abstract from Atlanten 1909: 601—632; Notes on the shore Vegetation of the Danish West Indian Islands. Botanisk Tidsskrift XXIX: 201—259. — BOLDINGH, I: The Flora of the Dutch West Indian Islands St. Eustatius, Saba and St. Martin. Leyden 1909; pages X and 1—321. 1909.

*reum.* Elsewhere among the mangroves are found *Avicennia nitida*, *Laguncularia racemosa*, *Anona palustris*, *Conocarpus erectus* and occasionally *Bucida buceras*.

Among the herbaceous plants at the edge of the lagoons may be mentioned Heliotropium curassavicum, Batis maritima, Portulaca pilosa, Herpestis Monniera, Chenopodium ambrosioides, Pectis humifusa and Capraria biflora.

In the shallow water among the roots of the mangroves, the phytogeographically inclined botanist finds Caulerpa verticillata, Bryopsis plumosa, Codium tomentosum, Catenella opuntia and species of the genera Bostrychium and Acanthophora, together with Penicillus capitatus, Udotea flabellata, Halimeda tuna, H. tridentata, Caulerpa plumaris, C. crassifolia var. mexicana, C. cupressoides.

The Sandy Alkaline Plain Formation vegetation of this formation is encountered in the neighborhood of the salt ponds, where the sandy soil frequently shows an incrustation of salt. Again such plains are separated from the sea by a barrier of beach sand. Where the land becomes firm are found Laguncularia racemosa, Avicennia nitida, Conocarpus erectus together with Fimbristylis ferrugineus, Pluchea odorata and Wedelia buphthalmoides. The herbaceous plants, however, which characterize the bare stretches of salt and sand are Batis maritima, Salicornia ambigua, Sesuvium portulacastrum, Atriplex cristata, Philoxerus vermiculatus, Stenotaphrum americanum, Herpestis Monniera, Cyperus viscosus.

*Chaparral Formation.* This is found on small islands and in the southern parts of St. Croix and the Virgin group. Such a coppice has a grayish parched aspect owing to the hoary or spiny covering of many of the plants and occupies about one-third part of the surface of the group.

Here are found in dense association Bromelia pinguin, Cereus floccosus, Opuntia tuna, Leucaena glauca, Randia aculeata, Pithecolobium unguis-cati. Among the larger trees of such thickets may be mentioned Crescentia cujete, Pisonia subcordata together with those hardly less inferior in size, viz.: Comocladia ilicifolia, Elaeodendron xylocarpum, Bucida buceras, Tecoma leucoxylon. The height of the vegetation varies; for example, the botanist finds species of Croton (C. flavens, C. astroites) two or three meters tall, associated with Lantana involucrata, L. camara, Corchorus hirsutus and Melochia tomentosa of a less height. The crown of several trees shape themselves in growth like an umbrella. Such are Randia aculeata, Citharexylum cinereum, Antherylium Rohrii. Lianes are well represented in the chaparral by Bignonia unguis-cati, Metastelma albiflorum, Ipomoea arenaria, Serjania lucida, Cissus trifoliata, Tragia volubilis, Echites suberecta, and Tournefortia volubilis. The epiphytes all belong to the genus Tillandsia including such species as T. utriculata and T. recurvata. The parasites are Loranthus emarginatus and a Phoradendron.

Hardly to be separated from the Chaparral Formation and yet sufficiently distinct to merit attention is a formation first named by Baron EGGERS, the Croton Formation. This formation consists of plants which in various ways have become adapted to resist the effects of a dry climate, and to exist on a barren rocky soil always found where the moisture is not sufficient to decompose the natural surface of the rock. Thus, some of these plants, as of the genus Croton, have leaves, which, like the stem, are covered with scales and hairs, containing besides aromatic oils which tend to reduce transpiration. Here in the island of St. Croix where this sort of vegetation is typically developed we find Sideroxylon, Bursera, Randia, Acacia, Leucaena, together with Croton, Melochia, Corchorus, Wedelia, Waltheria, Solanum aculeatissimum, S. igneum, S. bahamense, Cordia, Hibiscus, Malvastrum. Other members of this formation are Haematoxylon campechianum, Parkinsonia aculeata, Clerodendron aculeatum, Anthacanthus spinosus, Castela erecta and Argithamnia fasciculata. The lianes of this coppice are Metastelma albiflorum and Gonolobus maritimus. The succulent plants which are markedly xerophytic and which may be considered as constituents of the croton vegetation are Bromelia pinguin, Melocactus communis, Opuntia tuna,

O. curassavica, O. spinosissima and Cereus floccosus. All of these plants are more or less frequent and help to make such thickets almost impenetrable.

*Tropic Forest Formation.* The ravines, as well as the northern and western parts of the islands, are often covered with a growth of tall trees, forming a forest composed of species partly evergreen and partly with deciduous foliage. The area covered by this formation may be taken, according to EGGERS (1879), to be about one fifth of the whole surface, the best wooded islands being St. John, Vieques and the least wooded ones St. Thomas and Virgin Gorda. As nearly everywhere in the tropics, this forest is composed of many different species of trees mixed together, a gregarious growth being very rare.

In the interior of St. Thomas, we find the following trees in this formation: Bucida buceras, Melicocca bijuga, Mammea americana, Clusia rosea, Ceiba pentandra (= Eriodendron anfractuosum) and species of such genera as Ficus, Sapindus, Pisonia and Eugenia. Liane vegetation reaches here its most pronounced development, but species are much the same as in the chaparral formation. This forest also abounds in ferns and aroids, such as species of Adiantum and Polypodium, Blechnum occidentale, Anthurium Huegelii and A. cordifolium. Epiphytic orchids also form an element in this forest.

On St. John the trees of this forest formation are Tecoma leucoxylon, Andira inermis, Zanthoxylum clava-herculis, Morisonia americana, Mammea americana. In the shade of the trees BOERGESEN and PAULSEN found a climbing fern Polypodium Swartzii, Polypodium phyllitidis, Blechnum occidentale, Polypodium tetragonum and the climbing aroid Philodendron giganteum. A tall grass Pharus glaber also exists in the shade of the forest trees together with an exotic Bryophyllum calycinum.

The island of St. Croix possesses a forest in which tree species of such genera as Cicca, Eriodendron, Anacardium, Swietenia and Oreodoxa abound together with Hura crepitans and Andira inermis. Near the eastern end of the island is a true forest which EGGERS called by the name Eriodendron vegetation, which consists of such trees as Ceiba (Eriodendron)[1], Eugenia, Anona, Tetrazygia, Tecoma stans (an evergreen shrub), Bucida buceras, Mammea, Coccoloba barbadensis, Trichilia, Hura, Artocarpus incisa (introduced), Carica papaya, Cecropia peltata, together with such lianes, as Cissampelos pareira, Cissus trifoliata, sicyoides, and epiphytic on trees Polypodium Swartzii, Epidendrum ciliare. Pendant from the branches of Eriodendron is an abundance of the Spanish moss, Tillandsia usneoides.

## 2. Bahaman Region.

This region comprises the islands and cays (keys) which form the Bahaman Archipelago, together with the southern end of the Floridan Peninsula. The islands and the mainland are mostly low with little topographic relief and many of the cays are scarcely above water at high tide. The region abounds in coral reefs and submerged banks upon which grow the characteristic algae of such rock deposits. The vegetation impresses the traveller by its low, monotonous growth. The color scheme, according to my observations, is a dull, grayish green relieved occasionally by dashes of more brilliant color; but the glare of the sun on the eolian sand and rocks is little relieved by the

1) HOWE, MARSHALL A.: Some Photographs of the silk-cotton Tree with Remarks on the early Records of its Occurrence in America; Torreya VI: 217—231. Nov. 1906.

trees, which are found as a scrubby coppice growth. The arid conditions, which generally prevail, are due to the porous rock which prohibits the appearance of living streams of water and to occasional periods of excessive drought. Salt lakes and marshes abound and mangrove swamps lend variety to an otherwise monotonous landscape. There is little or no soil, but the eolian rocks are fairly honeycombed with holes, pits and cavities of all sizes; often sharp, jagged points project, making walking difficult.

Such environmental conditions, however, have occasioned corresponding adaptations of habit and structure in the plants of the region. The plants of the sand dunes, salt marshes, mangrove swamps, rock surfaces possess many interesting and peculiar adaptations. According to COKER, for example, the old leaves of *Rhizophora mangle* become much thicker and change their function from photosynthesis to water storage.

## a) Insular Area.

This corresponds territorially with the archipelago of islands and cays. Our knowledge of the flora of these islands has been extended recently by the expeditions under the auspices of the New York Botanical Garden and the Geographical Society of Baltimore [1]). The author visited the group for botanic purposes at Great Inagua in the summer of 1901. The following formations have been recognized and may be described in the pages that follow.

Beginning seaward with the Strand Formation of the several islands and cays, the following associations may be recognized: Ipomoea pes-caprae Association. On the south side of New Providence, *Ipomoea pes-caprae* is by no means abundant and where it does not occur its place is taken by grasses: *Paspalum vaginatum* and *Sporobolus virginicus*. This grass strip, according to COKER, varies from 1 to 10 feet, beginning at high-water mark and running back.

The Uniola-Tournefortia Association in New Providence occupies the gently sloping, or in some places quite level, sandy strip that extends to the scrubby coppice behind. *Uniola paniculata* is scattered at intervals with large clumps of *Tournefortia gnaphaloides*, *Scaevola Plumieri*, together with *Suriana maritima*, *Salmea petrochioides*, *Strumpfia maritima*, *Borrichia glabra*, *Ambrosia hispida* (in open spots), *Sesuvium portulacastrum*. On the eastern beach of Eleuthera there are dunes 40 feet high. The beach at the foot of the dunes is covered at high-tide mark by *Uniola*, *Tournefortia*, *Iva imbricata*, *Cakile aequalis*, behind which is a fringe of tall *Suriana* with which is mixed *Salmea* and *Cenchrus tribuloides*. Scattered individuals of *Agave ri-*

1) NORTHROP, ALICE: Flora of New Providence and Andros. Memoirs Torrey Botanical Club XII No. 1, pages 1—98 Dec. 1902; BRITTON, N. L.: Report on Exploration of the Bahamas. Journal New York Botanical Garden V: 201, Nov. 1904; NASH, GEO. V.: Botanical Exploration of the Inagua Islands, Bahamas, do VI: 1. Jan. 1905; COKER, W. C.: Vegetation of Bahama Islands. The Bahama Islands 1905: 185—270 see Bibliogr. pp. 87—92.

*gida* cover the seaward slope of the dunes and their outer ridges are occupied by *Uniola*, *Cyperus brunneus* and fine beds of *Hymenocallis arenicola*. The same association occupies the rocky, or sandy ledge that runs along the western beach of Watlings Island at high-tide mark. The rock is not hard, but is covered with sand in which grow *Tournefortia gnaphaloides*, *Suriana maritima* and the trailing *Ambrosia hispida*.

Chrysobalanus (cocoa-plum) Association. This occupies the rounded sandy elevations on Watlings Island immediately behind the flat area of the above. The association is almost pure consisting of Chrysobalanus fellocarpus and C. icaco. Coccoloba uvifera, Ilex Krugiana, Ernodea littoralis, Genipa clusiifolia, Rhus Metopium, Reynosia septentrionalis, and Eugenia confusa appear scattered in this formation.

The Sabal-Lantana Association of Sabal (Inodes) palmetto (see plate IX at p. 433) on Watlings Island forms a very distinct line. The trees are 20 to 25 feet high with which are associated Phyllanthus epiphyllanthus, Chloris petraea, Cenchrus tribuloides and Dalbergia ecastophyllum.

The Pithecolobium-Salmea Association begins on New Providence Island immediately behind the Uniola-Tournefortia Association. Its principal plants are according to COKER: Pithecolobium, Salmea, Torrubia, Jacquemontia, Erithalis, Lantana involucrata, Ernodea, Solanum bahamense and occasional tufts of Cyperus brunneus. The shrubs of this formation are low and dwarfed, generally not more than three feet high.

Erithalis-Reynosia (littoral sand-coppice) Association. The flat tops of sand ridges on New Providence Island are occupied by this association in which Erithalis fruticosa, Reynosia septentrionalis, Rhus Metopium, Torrubia, Salmea, Myrsine guianensis, Ilex Krugiana, Genipa clusiifolia, Acacia choriophylla, Bumelia cubensis and microphylla, Bourreria havanensis, and Uniola racemiflora are the principal constituents. At Powell's Point, Eleuthera, the most noticeable peculiarity of the coppice was the grouping of its different plants into almost pure association. For example, a pure growth of Reynosia septentrionalis would be succeeded by an equally pure growth of Pithecolobium keyense; this by Acacia choriophylla, and this by Eugenia buxifolia. Near Clarence Harbor, Long Island on the north slope of a line of hills occurs a low growth corresponding to this association. The constituents of this low scrub are Lantana, Erithalis, Pithecolobium, Cajanus cajan, Tecoma bahamensis, Psychotria undata, Reynosia, Eugenia, Tetrazygia, Croton, Phyllanthus, Smilax Beyrichii, Jacquemontia jamaicensis, and Stigmaphyllon Sagraeanum. Near the top of the hill occur fine specimens of Pilocereus lanuginosa.

Coccothrinax Association. The characteristic tree is the silver palm, Coccothrinax jucunda, which grows on the inner slopes of ridges in New Providence and extends to the marshy depression behind. On Green Cay this palm is scattered in dry areas, but in lower damper places it is replaced by Thrinax bahamensis and these palms are associated with Pithecolobium, Jacquinia keyensis, Reynosia septentrionalis, Cassia lineata and Antirrhaea myrtifolia. — Along the beach on Watlings Island are low sand dunes where Coccothrinax jucunda is abundant, but the associated species are different from those species mentioned above. This association on Great Inagua Island occupies the "whiteland" region where the associated species are Coccothrinax jucunda and Jacquinia keyensis.

*Fresh-water Formations.* A Marsh Formation occurs in New Providence behind the beach where the soil is saturated or entirely covered with shallow water. *Sabal Palmetto*, the thatch palm (see pl. IX, p. 433), is abundant on the damp margins of the marsh and a few also enter the marsh, along the edge of which also grow *Mikania heterophylla*, *Centella repanda*, *Cladium effusum*, *Sabbatia campanulata* and *Ipomoea sagittata*. *Anona palustris* occurs

further out and *Rhizophora mangle* gives evidence of the brackish character of the water. — *Sabal Palmetto* occurs also in a sand inlet in Eleuthera island, where it occupies a marshy depression, where it no doubt is able to procure supplies of fresh water. — About one mile from the shore on Cat Island are a series of fresh-water pools (unusual in the Bahamas) in which grow *Utricularia* sp., *Nymphaea ampla*, while along the edges were found *Spigelia anthelmia*, *Sabbatia campanulata*, *Centella repanda*. On New Providence, the plants of the fresh marshes are *Myrica cerifera*, *Baccharis angustifolia* and *Sagittaria lancifolia*.

*Salt Marsh-* and *Mangrove-Formations*. Directly south of Nassau, New Providence Island is a large tract of marshy land with a considerable pond of water that rises and falls with the tides. The rocks margining this pond are covered with a swamp marl favorable only for the growth of such resistant species as *Aster tenuifolius* and *Distichlis maritima*. Behind these where the honeycombed rock is exposed grow dwarf forms of *Conocarpus erectus* var. *sericea* and *Rhachicallis maritima* with *Cassytha* running along from plant to plant. — Certain depressions in Green Bay are brackish and here are found *Anona palustris*, *Cladium*, *Conocarpus*, *Avicennia nitida*. In a long, brackish marsh a few hundred feet behind the beach was a fine association of *Typha domingensis* and *Eleocharis cellulosa*. Except at this place, *Typha* was seen only on New Providence, where, according to COKER, it is abundant at Lake Killarney. The immediate shores of a large salt-water pond on Rum Cay are characterized by the presence of *Rhizophora mangle*.

A Conocarpus Flat Formation extends on Watlings Island some distance back from a marsh. The ground is a honeycombed rock with water in the holes. Conocarpus erectus var. sericea grows here in almost pure association. At certain places on Abaco, the Conocarpus-flat is bordered with an association of Aster tenuifolius, Distichlis maritima and Salicornia ambigua.

The Conocarpus-Mangrove Formation exists on Watlings Island about 8 feet high. Except near the shore of a lake where it occurs, there is a pure growth of Conocarpus, but on the water's edge Rhizophora mangle forms a fringe together with Avicennia nitida. On the sandy margins of the lake also grow Hippomane mancinella, Batis maritima and Lithophila vermicularis [1]).

Salinas Formation. This formation (also Swash) occupies depressions in the scrub in which has collected the wash from the surrounding ridges of rock or sand, the resulting soil being a sticky compound, especially when wet. The salinas are more or less occupied by ponds and lakes connected together in wet weather. The ground almost flat is covered with small mangroves, Rhizophora, the salt-bush, Avicennia and a low form of Conocarpus erectus not more than a few feet in height. One or two species of Salicornia also are found, and in general the plants of this formation are quite scattered, and a considerable distance apart. The monotony of the landscape is varied near the creeks by three species of palms: the "silver thatch", Thrinax bahamensis; the "hog cabbage", Cyclospathe Northropii; the "saw-tooth cabbage", Paurotis androsana: all of small size [2]).

The Savanna Formation is coincident with large flat plains in Great Inagua covered in great part with Sporobolus virginicus. Here and there

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1) COKER, W. C.: Loc. cit. p. 237.

2) See references to papers of NASH and NORTHROP quoted above.

small clumps of trees dot the surface of the savanna consisting of *Swietenia mahagoni*[1]). On Andros the savannas are level prairie-like stretches covered with a coarse sedge *Cladium jamaicense*, the saw grass of the natives. *Terminalia spinosa* forms occasional clumps while *Flaveria linearis*, *Polygala Boykinii*, *Eustoma exaltatum*, *Gerardia purpurea*, *Aletris bracteata*, *Spiranthes tortilis*, *Calopogon pulchellus*, *Buchnera elongata* and *Samolus ebracteatus* are also inhabitants of these savannas[2]).

Sea Cliffs and Rocks. The north shore of New Providence differs from the south shore by its rocky character. Sand covers the rocks in places. In many places, however, the exposed rocks are covered with a dense growth of *Rhachicallis maritima* and *Suriana maritima* in pure association. Behind this association is *Coccoloba uvifera* and *Genipa clusiifolia*.

On Andros Island, the rock surfaces are characterized by Portulaca oleracea and on the slopes of hills grow Lysiloma paucifolia, Swietenia mahagoni, Coccoloba laurifolia, Bursera simaruba, Acacia choriophylla, Rhus Metopium and Eugenia confusa. Covering the barren rocks behind the beach on Green Cay is a low growth of Ernodea littoralis, Genipa clusiifolia, Catesbaea fasciculata, Antirrhaea myrtifolia, while Passiflora foetida grows among these shrubs. The rocks behind this sand inlet show a low coppice of Sideroxylon mastichodendron, Zanthoxylum pterota, Coccoloba, Torrubia longifolia, Amyris elemifera, Bursera simaruba together with Opuntia tuna. — The bare rocks on Eleuthera support among other plants Suriana maritima, Borrichia glabra, Rhachicallis maritima, Sesuvium portulacastrum. — Growing in small rock pockets, according to my observations at Matthewtown, Great Inagua, grow Portulaca oleracea var. parvifolia, and back of this plant in the treeless area are found Coccoloba uvifera, Tournefortia gnaphalodes, Bucida buceras, Rhachicallis rupestris. These form an association which may be designated the Tournefortia-Coccoloba Association[3]).

The depressions in the rocky plain show a type of vegetation in every respect different from the ordinary level, which may be designated as Banana Holes. In such an hole on Eleuthera thirty feet across grew Anona palustris, Ficus sapotaefolia, Picramnia pentandra, Psychotria undata and Cladium effusum. Attached to the sides of the "sink" beneath its overhanging edges flourish Adiantum melanoleucum and Lindsaya clavata.

The absolutely bare rocks near Gregory Town, Eleuthera, are characterized in the crevices by *Serjania diversifolia*, *Cissus sicyoides*, *Ampelopsis* (*Parthenocissus*) *quinquefolia*, *Galactia Rudolphioides*, *Rhabdadenia biflora*, *Smilax Beyrichii*. In the deep depressions of these vine-clad rocks grow *Bursera simaruba*, *Bumelia microphylla*, *Ficus sapotaefolia* and *Phyllanthus epiphyllanthus*.

On the top of ridges on Rum Cay among the hard smooth rocks grow Gossypium barbadense (absolutely wild), Agave rigida, Plumeria obtusa, Guaiacum sanctum, Guettarda scabra, Bumelia loranthifolia, B. microphylla and Reynosia septentrionalis. — Growing on the rocks of Little Inagua Island were found by NASH Melocactus sp., Agave sp., Opuntia sp., Thrinax keyensis, Pilocereus sp., etc.

*Pine-Barren Formation.* The ground of this formation is either wet or dry. In New Providence and elsewhere in the Bahama islands the wet for-

1) NASH, G. V.: Loc. cit. p. 15.

2) NORTHROP, ALICE R.: New Providence and Andros. (1902.) See Bibliography p. 91.

3) HARSHBERGER, J. W.: Strand Flora of Great Inagua. (1903.) See Bibliogr. p. 89.

mation is composed of more or less honey-combed rock and has the water constantly within a few inches of the surface. This formation, according to COKER, differs from the typic pine-barrens in the occurrence of *Sabal Palmetto*, and differs from the wetter marsh in the presence of the pine, *Pinus caribaca* (= *P. Elliottii*, *bahamensis*).

The dominant growth is open and scattered and consists almost entirely of pines (20—25 feet tall) and palms (15—20 feet tall), Rhus Metopium, Exostemma caribaeum, and Coccoloba laurifolia are scattered here and there, but hardly reach the size of trees. The undergrowth is low and and open consisting of Corchorus hirsutus, Torrubia longifolia, Pithecolobium keyense, Tecoma bahamensis, Lantana involucrata, Cordia bahamensis, Bourreria havanensis, Byrsonima lucida and such vines as Smilax Beyrichii, Rajania hastata, Mikania heterophylla, and the parasite Cassytha filiformis. The principal herbaceous species in New Providence are Evolvulus sericeus, Turnera ulmifolia, Lippia stoechadifolia, Dicromena colorata, Chloris petraea and a little fern Ornithopteris adiantoides together with a species of Andropogon.

The wet pine barrens insensibly intergrade with the dry "pine yards". In New Providence[1]) it extends across the central part of the island to the base of the Blue Hills. *Pinus caribaca* (= *bahamensis*) rarely reaches a large size, being generally slender and from 20 to 35 feet high. *Coccothrinax jucunda* is next to the pine the most conspicuous and abundant tree occasionally 12 feet tall. The orchid *Bletia verecunda* is common in rock holes.

In Andros[2]), *Pteris* (*Pteridium*) *caudata* is very characteristic of the pine barrens. It often forms impenetrable thickets six or seven feet in height associated with *Acacia choriophylla*, *Ascyrum hypericoides*, *Tetrazygia bicolor*, *Linum bahamense*, *Ernodea littoralis*, *Vernonia bahamensis*, *Dicromena colorata* and *Bletia verecunda*. In many parts of the pine barrens on Andros, there is no underbrush, nothing but a coarse grass, *Andropogon* sp., relieved here and there by the crimson flowers of *Ipomoea repanda*.

Among the pines, which grow on Abaco, are found, according to COKER, Tetrazygia bicolor, Cordia bahamensis, Ichthyomethia piscipula, Bursera simaruba, Rhus Metopium, Swietenia mahagoni, Tecoma bahamensis, Bumelia microphylla, Acacia choriophylla, Anthacanthus acicularis, Duranta repens, Ernodea littoralis, Myrica cerifera, Mikania heterophylla, Rajania hastata, Byrsonima lucida, Erythroxylon brevipes, Morinda roioc, Hypelate trifoliata, Bourreria havanensis, Hypelate paniculata, Vernonia bahamensis, Gymnanthes lucida, Eugenia buxifolia, Erithalis fruticosa, Rapania guyanensis, and Coccoloba laurifolia, Ernodea Cokeri and Galium hispidulum. — According to BRITTON[3]), an extensive pine forest similar to that on New Providence extends from Eight Mile Rocks nearly or quite to the extreme eastern end of Great Bahama Island. The flora of this pine forest is similar to that on New Providence Island.

*Low Thicket Formation.* These thickets are almost impenetrable because the trees and shrubs grow straight up and close together and the growth of epiphytes (bromeliads and orchids) upon them is extraordinary. An essentially leafless *Vanilla* scrambles through and upon the shrubs, and with it *Arthrostylidium*, a slender bamboo. This kind of thicket covers most of the northern

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1) COKER, W. C.: Loc. cit. page 219.

2) NORTHROP, ALICE R.: New Providence and Andros, see Bibliogr. p. 91.

3) BRITTON, N. L.: Explorations in the Bahamas. (1905.) See Bibliogr. p. 87.

slopes of the Blue Hills in New Providence Island and a large part of the flat country on the north and east sides of that island.

This coppice (the average height of which is 10 to 15 feet) consists of such small trees and shrubs as Hypelate paniculata, Bourreria havanensis, Coccoloba laurifolia, Bumelia loranthifolia, Erithalis fruticosa, Haematoxylon campechianum, Picramnia pentandra, Byrsonima lucida, Maba caribaea, Anastraphia Northropiana, Tecoma bahamensis, Torrubia longifolia, T. obtusata, Psychotria undata, Ocotea Catesbyana, Zanthoxylum pterota, Duranta repens, Leucaena glauca, Krugiodendron ferreum, Helicteres spiralis, Melicocca bijuga, Croton eluteria and such vines as Smilax havanensis, S. oblongata var. viscifolia, S. Beyrichii, Jacquemontia jamaicensis, Triopteris rigida and the parasite Cassytha filiformis, together with Vanilla articulata.

The low scrub on Eleuthera occupies an elevated, rocky plain and consists of *Bumelia loranthifolia*, *Coccoloba laurifolia*, *Zanthoxylum pterota*, *Bursera simaruba*, *Torrubia longifolia*, *Bumelia microphylla*, *Picrodendron baccatum* var. *bahamense*, *Ichthyomethia piscipula*, *Pithecolobium keyense*, *Acacia choriophylla*, *Haematoxylon campechianum* with such vines as *Gouania domingensis* and *Parthenocissus Ampelopsis* (*Quinaria*) *quinquefolia*. — The long eastern slopes of the high ridge is covered by a low scrub, unlike anything on any of the other islands and composed of *Baccharis dioica*, *Croton eluteria*, *Phyllanthus epiphyllanthus*, *Anthacanthus acicularis*, *Lantana crocea*, *L. involucrata*, *Acacia choriophylla*, *Bumelia microphylla* and *Jacquinia keyensis* [1].

The low coppice growth on Watlings Island is not often more than 8 or 10 feet high and is composed principally of the following species: Croton lucidus, Calliandra haematomma, Amyris elemifera, Bourreria havanensis, Erithalis fruticosa, Coccoloba laurifolia, C. Krugii, Raponia guyanensis, Reynosia septentrionalis, Bumelia microphylla, Mimusops Sieberi, Rhus Metopium, Calyptranthes pallens, Exostemma caribaeum, Buxus bahamensis, Phalanthus myrtilloides, Eugenia confusa, E. buxifolia, Ilex Krugiana, Maytenus buxifolia, Byrsonima lucida and Gymnanthes lucida.

On Great Inagna, according to my observations[2], the low thicket of the strand consists of an association of Phyllanthus epiphyllanthus, Acacia farnesiana, Tournefortia volubilis, Xylosma buxifolia, Opuntia sp., and Urechites suberecta, a climbing plant which grows over the components of the thicket. On James Hill (90 feet elevation), Great Inagua, according to NASH[3], grow a species of Pilocerus, Opuntia Dillenii, another Opuntia of the spinosissima section and a species of the genus Mamillaria (Cactus) growing in great profusion. Tillandsia usneoides is also an element of this scrub, while in other places in the coppice occur Mimosa bahamensis, Clusia rosea, Pseudophoenix Sargentii, Agave sp., Melocactus sp., etc. The shrubs and trees of this coppice on the south shore do not attain a height of more than a foot or a little over, because this shore is subjected during the summer months to the full force of the trade winds which blow from the northeast.

The low thicket on Grand Turk Island consists of a shrubby *Pithecolobium* 10 to 15 feet tall and an extensive cactus vegetation composed of *Opuntia Nashii*, *O. tuna*, *O. Dillenii* while *Euphorbia vaginulata*, found on sand ridges and called milk bush by the natives, gives a grey-brown aspect to the landscape as it does on Watlings Island where it is also found. *Pseudophoenix Sargentii* exists by the thousands on the island of Little San Salvador, and elsewhere in the Bahamas it is abundant.

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1) COKER: Loc. cit.: 229.

2) HARSHBERGER, J. W.: Strand Flora of Great Inagua. (1903.) See Bibliogr. p. 89.

3) NASH, G. V.: Botanical Exploration of the Inagua Islands. (1905.) See Bibliogr. p. 90.

High Thicket Formation. In this type of thicket in New Providence, there is very little undergrowth on the densely shaded ground. The largest tree of this coppice which covers the southern slope of the Blue Hills on the Bahama black loam soils is Lysiloma latisiliqua, the wild tamarind. Swietenia mahagoni, Simaruba glauca and Pera bumeliaefolia are also large trees.

The high-coppice formation on Watlings Island consists of large trees. Here are found in association Gymnanthes lucida, Guaiacum sanctum, Bourreria havanensis, Ichthyomethia piscipula, Bursera simaruba, Acacia choriophylla, Tecoma bahamensis, Thouinia discolor, Chiococca parvifolia, Humelia microphylla, Cajanus cajan, Citharexylum quadrangulare, and such vines as Smilax Beyrichii and Serjania subdentata, together with Thrinax bahamensis.

On Long Island the most abundant constituents of this formation are Lysiloma bahamensis, Rapania guyanensis, Guaiacum sanctum, Erythroxylon brevipes, Tetrazygia bicolor, Krugiodendron ferreum, Tecoma bahamensis, Caesalpinia vesicaria, Zanthoxylum caribaeum, Reynosia septentrionalis, Amyris elemifera, Maytenus buxifolia, Gymnanthes lucida, Exostemma caribaeum, Hypelate trifoliata, Torrubia longifolia and Bursera simaruba, which reach a common height of 15 to 20 feet.

*Tropic Forest Formation.* On Mangrove Cay, Andros, the botanist encounters, according to COKER, a true forest where are found *Lysiloma paucifolia*, *L. latisiliqua*, *Zanthoxylum coriaceum*, *Hypelate trifoliata*, which reach a height of 40 to 50 feet, while as secondary species 30 to 40 feet tall may be mentioned *Coccoloba laurifolia*, *Rhus Metopium*, *Ichthyomethia piscipula* and *Swietenia mahagoni*, all contributing to a thick growth and dense shade.

## b) Floridan Area.

Phytogeographically this area comprises the southern extremity of peninsular Florida and the keys (cays) which lie off its coast. The geology of southern Florida is similar to that of the Bahama islands and the botanist would naturally exspect to find, that controlled by the edaphic conditions, there would be many species of plants in common. A statistic enumeration shows this to be the case. The honey-combed limestone rock supports a luxuriant vegetation and a reference to a former page (229—232) will present the main facts concerning the principles underlying the distribution of Floridan plants. The following are the principal plant formations of this area:

*Mangrove Formation.* The mangrove formation represents an important element in the flora of southern Florida. The mangrove swamps are particularly abundant along salt or brackish shores and along the sea islands, the so-called Florida Keys [1]. Their vegetation is confined almost exclusively to the mangroves (*Rhizophora mangle*) and such few Tillandsias and orchids as grow upon their branches. Frequently on the borders of these swamps occur a large, showy fern *Acrostichum aureum*. Many of the keys are surrounded by a girdle of mangrove trees.

In detail, according to the botanic exploration of the sand keys west of Key West by LANSING [2]) the mangrove formation is distributed, as follows: Key C. consists almost entirely of a colony of

1) PHILLIPS, O. P.: How the Mangrove Trees add new Land to Florida. Journal of Geography II: 1—14; SMALL, J. K.: Report on Exploration in tropical Florida. Journal New York Botanical Garden V: 49 March 1904; VAUGHAN, T. WAYLAND: The geologic Work of the Mangroves in southern Florida. Smithsonian Miscellaneous Collections LII: 461—464 with 6 plates.

2) MILLSPAUGH, C. F.: Sand keys of Florida (1907): see Bibliogr. p. 90.

Rhizophora mangle bordered by Laguncularia racemosa and Avicennia nitida. The northern side of Man Key is occupied by a broad area of mangrove vegetation from which Laguncularia racemosa is absent. Woman Key is characterized by extended areas of the mangrove associated with Laguncularia racemosa and Avicennia nitida while Ballast Key has only a small corner occupied by such plants. Boca Grande Key with the exception of the narrow area of sand is a mangrove island. All of the islets of the Marquesas group of keys with the exception of one small key are characterized by extensive growths of the mangrove, while the keys of the Tortugas group, as also Bird and Loggerhead keys are destitute of the mangrove. The small keys north and west of Woman Key, viz., Mule, Cottrell, Mullet, East and West Crawfish and Conch keys are mangrove islets only. Changes are constantly taking place in these islands owing to the extension of the mangroves and the action of the wind and waves on the white, coral sand.

The islands along the west coast of Florida are largely covered by this formation. Shoals are formed by the action of the waves, and on these the mangrove finally takes root, and the roots catch and retain seaweeds and other floating matter, building such material about the trees. On the seaward side, banks of shell are formed and the interior gradually becomes a typic hammock.

*Mud Flat and Strand Formation.* Along the edges of the mangrove thickets are mud flats which are found on many of the islets which form the Florida keys.

The vegetation on the mud flats of Key C. consists of Salicornia ambigua, Batis maritima, Monanthochloë littoralis, Sesuvium portulacastrum. On Man Key, the tenants of such flats are Borrichia arborescens, Pithecolobium guadalupense, Avicennia nitida, Alternanthera brasiliana, Batis maritima, Conocarpus erecta, Euphorbia (Poinsettia) havanensis, while on the mud flats of Woman Key are separated colonies of Suriana maritima, Sesuvium portulacastrum, Cyperus brunneus, Atriplex cristata, etc.

The islet of the Marquesas Group designated B. by LANSING has an association of mud flat plants, viz., Dondia linearis, Laguncularia racemosa, Avicennia nitida, Distichlis maritima. The mud flat vegetation is not typically developed into a formation on any of the other islets of the Marquesas group, except on Round Island where Laguncularia racemosa and Salicornia ambigua are characteristic while on Marquesas J. the mangrove border, while characterized by Avicennia nitida, here shows for the first time in the group a full substitution of Conocarpus erectus for Laguncularia racemosa. This formation is unknown on the islets of the Tortugas group.

Historically the sea-strand formation is an old one floristically speaking. The east coast of Florida, as far south, as Biscayne Key (lat. 26° 75′ north), is lined by low sand dunes ranging from ten to thirty feet in height. Shoals are formed out at sea by the action of currents and tides; and when these emerge and become dry, such dune-building plants as *Sesuvium portulacastrum, Iva imbricata, Cakile maritima, Panicum amarum* take possession of them and help to form a low line of dunes. *Uniola paniculata* is the main sand-binding grass to be found on the top and seaward side of the first line of dunes. Here it forms almost 75 per cent of the vegetation and may be properly termed the Uniola association. Species of *Spartina*, *Panicum*, *Euphorbia* and *Opuntia* are found mingled in this association together with *Ipomoea pes-caprae*, *Yucca*, *Croton maritimus*, *Serenoa serrulata* (see plate VI, p. 306). At the base of the main line of dunes, according to WEBBER [1]), are a number of dune-builders: *Panicum amarum*, *Ipomoea pes-caprae* and *littoralis*, *Iva imbricata*, *Cakile maritima* etc.

1) WEBBER, H. J.: Strand Flora of Florida (1898): see Bibliogr. p. 71.

The most interesting strand plant of the open beaches of the keys along the mainland is *Agave decipiens* widely distributed along the strand of tropic Florida, being disseminated almost wholly by bulblets produced in place of flowers. On sandy stretches occur *Hymenocallis caymanensis*, *Coccoloba*, *Ipomoea*, *Ernodes* and *Alternanthera floridana*.

Shell Bank Formation. On the seaward side of mangrove islands shell banks are formed by the action of the tides and waves and these become occupied by vegetation which consists of Forestiera porulosa, Myrsine rapanea (= Rapanea guyanensis), Coccoloba uvifera and Juniperus virginiana with Iva imbricata, Cakile maritima and Ipomoea pes-caprae at the margin of the water. — The shell islands of the coast consisting of oyster shells are inhabited by Yucca aloifolia, Forestiera porulosa, Quercus virens (= Q. virginiana), Opuntia pes-corvi, O. vulgaris, Mentzelia floridana, and Vincetoxicum scoparium climbs over these plants while Passiflora suberosa and Cocculus carolinus carpet the pavement of white shells. Chiococca racemosa and Psychotria rufescens also occur[1].

*Cypress Swamp Formation.* This formation is found in many parts of southern Florida, but nowhere better developed than in the Big Cypress Swamp west of the everglades and limited on the gulf side by the mangrove swamps which fringe the coast. It can be located by its proximity to Gallivans Bay and Cape Romano. The southeastern limit of *Taxodium distichum*, the principal tree of this formation, has been placed by Professor SARGENT at Mosquito Inlet (about lat. 29°) on the east coast and at Cape Romano (about lat. 26°) on the west coast, but SMALL has found it extending down the Miami River and has found it in the everglades nearby.

Little is known of the composition of this formation in Florida. The larger and smaller trees form with the lesser vegetation an almost impassable growth. The larger trees are buttressed and large root growths the so-called "knees" project from the soil or above the surface of the water. This forest is so dense that perpetual twilight is found beneath the trees and the silence is relieved only by the occasional splash of an alligator in the streams which sluggishly meander through the depths of the forest.

*Everglade Formation.* The everglades historically speaking may be older than the pine woods. Their origin is as follows[2]:

The chain of keys surrounded by the everglades are duplicated by the outer series of Florida keys. Before these everglade hammock islands were raised to their present altitude, they were probably surrounded by a shallow sea. This being the case, we can easily account for the tropic American flora now inhabiting them. After sufficient elevation had taken place, the surrounding sea was transformed into the vast spring known as the everglades and a northern flora advanced into this area thus surrounding and isolating a totally different tropic flora. (See ante Part III, page 201, 229.)

The everglades cover an area about one hundred miles wide and perhaps one hundred and fifty miles long, the elevation being about eighteen feet above

1) CURTISS, A. H.: A Visit to the Shell Islands of Florida. Botanical Gazette IV: 117, 132, 154. See also Bibliogr. p. 67.

2) HARSHBERGER, JOHN W.: The comparative Age of the different floristic Elements of eastern North America. Proc. Acad. Nat. Sc. Phila. 1904: 613. — SMALL, J. K.: Southern Florida (1907) see Bibliogr. p. 92.

sea-level. This formation consists of an extended saw-grass swamp (*Cladium effusum*) merging in places with pine land, prairies, cypress swamps, custard apple (*Anona glabra*) swamps and traversed by winding river channels, occasionally filled with water lettuce, *Pistia stratiotes*, with the water perfectly clear and pure, and covered with scattered hammock-lands. Its flora consists of grasses, sedges and other herbaceous plants, among which are many aquatic and mud-inhabiting species (f. e. *Peltandra virginica*, *Saururus cernuus*) less than one-half as many species as grow either in the hammocks or the pine-lands. This formation partially surrounds and intersects the sandrock ridge. Structurally it consists of a marsh with scattered hammocks, while its flora is composed of plants (*Apios tuberosa* etc.) of far northern range and therefore mainly of a different character from those found in either the pinelands, or the hammocks, which are characterized by tropic palms, cycads, orchids and bromeliads.

The shores of the streams by which the everglades are entered are covered with rank growths of the cocoa-plum, *Chrysobalanus icaco.* This same species grows about the edges of the glades producing blue fruit on the eastern edge and white fruit toward the west.

*Savanna-* and *Prairie Formation.* With the appearance of level plains by the removal of the shallow sea over a sandy bottom, the isolated trees, which associated together constitute the savanna formation, appeared and clothed the ground. Imperceptibly these savannas are transformed into pine-land. — When the swamps, or everglades are raised a few feet by the deposition of decaying vegetable matter and silt the character of the vegetation completely changes. Grassland is formed and the hard, rank grasses, palmetto scrub and reeds give place to growths of "blue joint", *Andropogon virginicus* and other grasses (*Syntherisma*, *Panicum virgatum*) which can be used for fodder and hay.

*Pine Barren Formation.* (See plate VI to page 306: Southern Florida.) When the grassland is invaded by trees, pineland results, if that invasion is sufficient to close up the grassy stretches with a continuous forest growth. It may also be formed by the encroachment of trees on the savanna formation. *Pinus caribaea* (= *P. heterophylla* = *P. cubensis*) is the dominant tree of the pine barrens associated with numerous shrubs, shrubby herbs and herbaceous perennials. The exposed coral rock of the slight elevations maintain not only more species than the slight depressions, but also more individuals, or in other words the more eroded and needle-shaped the condition of the coral rock with apparently barely enough soil to support plant life, the more diversified and abundant the vegetation. *Pinus clausa* occurs in the pine scrub associated with *Ceratiola ericoides.*

These pinelands are light and airy, the timber affording little shade. Besides Pinus caribaea several palms are conspicuous elements of the landscape, viz: Serenoa serrulata, Coccothrinax jucunda (= Thrinax argentea), C. Garberi (on dry coral ridges along Biscayne Bay), Sabal megacarpa (= S. Etonia), and Zamia floridana. The most abundant fern of the pine barrens is Pteridium aquilinum var. pseudocaudatum found in dry soil.

The keys on the western side of Bahia Honda are covered with low and thin forests composed of Pinus caribaea, Coccothrinax jucunda together with Serenoa serrulata and Myrica cerifera. The central portion of Big Pine Key, according to Stewardson Brown, is covered with Pinus caribaea (70—80 feet) with palms underneath and the same is true for Little Pine Key, while Croton linearis, Galactia volubilis, Dolicholus parvifolius, Chamaecrista grammica, Mikania heterophylla, Pteridium caudatum, Dichromena colorata and Pteris longifolia are abundant plants in the pine lands of the keys.

There are two types of pine barrens in Florida: first, the "flat woods", with numerous slight depressions, which are ponds in wet weather and are usually grown up with cypress and gum; second, the rolling barrens drained by small streams, which are bordered by almost impenetrable thickets and stretches of swamp [1]).

*Hammock Formation.* The hammocks consist of isolated groups of hard-wood trees, shrubs and vines. These hammocks have an overlying soil thicker than the pine-lands due to the accumulation of vegetal detritus, occasionally 1—2 feet deep, and they vary in size from an acre to many hundred acres, and are scattered as islands in the everglades and pine forests. The trees, shrubs and vines harbor a large number of plants of various categories. The growth of epiphytes is especially striking, for in numerous cases the tree trunks and branches are loaded with air plants, and the growth is so crowded that many of the orchids and bromeliads are forced to grow on the ground, or on the neighboring pine trees. This hammock formation includes the great majority of flowering plants now known to be common to the West Indies and Florida. The area occupied by the hammocks is insignificant as compared with that of the pineland, yet there are nearly as many species of flowering plants growing in these small areas, as there are in the vast pine-lands.

SMALL[2]) describes a hammock which is actually being destroyed by the excessive development of epiphytes. The epiphytic bromeliads and orchids having taken possession of every available bit of surface on the larger trees have broken to the ground, where the epiphytes completely cover the floor of the hammock and the smaller trees beneath the larger ones. In addition to the bromeliad-orchid flora, the hammocks are characterized by ferns of a tropic type, such as: Polypodium incanum (on oaks), P. phyllitidis, Pteris cretica, Adiantum tenerum, Aspidium trifoliatum. Some of the species of ferns are confined to the trees, others to the curious and treacherous sink holes, while the ground is often carpeted with filmy ferns or gigantic sword ferns. Several of the hammocks are characterized by the presence of palms: Pseudophoenix Sargentii (Elliott's Key), Oreodoxa (Roystonea) regia (Royal Palm Hammock) and such orchids as Dendrophylax Lindenii (on the trunks of the royal palm), Epidendrum nocturnum, E. rigidum. The gumbo limbo Bursera simaruba is a constituent of the hammocks on Boca Chica Key. The Great Gulf Hammock according to GARBER[3]) yielded the following plants: Chrysobalanus oblongifolius, Galactia Elliottii, Sclerolepis verticillata, Boltonia diffusa, Senecio lobatus, Vaccinium tenellum, Sabbatia gracilis, Asclepias perennis, Sagittaria graminea, Calopogon multiflorus, Smilax Beyrichii, Dichromena colorata, Rhynchospora macrostachya, Carex gigantea, C. cherokeensis, C. verrucosa, Paspalum undulatum, Panicum gymnocarpum, etc.

1) CURTISS, A. H.: Among Florida Ferns. Plant World V: 68 April 1902.

2) SMALL, J. K.: Report upon further exploration of southern Florida. Journal New York Botanical Garden V: 157 August 1904.

3) GARBER, A. P.: The April Flora of Cedar Keys, Fla. Botanical Gazette II: 112.

The chain of everglade islands or keys are similar to the Florida Keys both in its crescent shape and in its flora. It is surrounded by the everglades, except where the upper islands touch Biscayne Bay. Before these hammock lands were elevated to their present level above the sea, they were probably surrounded by a shallow sea later transformed into the everglades. Their total area is perhaps about 150 square miles. SMALL[1]) who has explored them more carefully than any other botanist finds that between five and six hundred species of native flowering plants occur on them. He has now established the fact that considerably more than one half of the species found on the islands south of Miami are also native in Cuba and the Bahamas, and so it happens that an older tropic flora is completely surrounded by a newer vegetation introduced from higher northern regions.

These islands, or hammocks, scattered through the everglades are covered with luxuriant virgin forests. *Quercus virens* (= *Q. virginiana*) and *Persea borbonia* are present in large numbers interspersed with wild lemon *Citrus limonium*, wild orange *Citrus aurantium* and the wild cucumber while on Royal Palm Hammock occur *Smilax laurifolia*, *Salix longipes*, *Magnolia glauca*, *Ampelopsis* (*Parthenocissus*) *quinquefolia*, *Diospyros virginiana*, *Callicarpa americana* and *Cephalanthus occidentalis*. *Carica papaya*, *Anona glabra*, *Zanthoxylum Clava-Herculis* are of frequent occurrence, and here and there, governed by the size and elevation of the islands, are the cabbage palmetto, *Sabal Palmetto*, *Pinus caribaea* and *Ficus aurea* grow to enormous size in some of the hammocks strangling other forest trees[2]). Throughout there is a phenomenal growth of lianes. Wherever the land is dry enough, the coontie *Zamia floridana* flourishes.

There are several other plant formations to be recognized in southern Florida, but information concerning them is so meagre that it is impossible to give an exact statement concerning them. It is one of the phytogeographic surprises that we have such little information about a region of such marked botanic interest[3]).

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1) SMALL, J. K.: Exploration of Southern Florida. Journal New York Botanical Garden VIII: 23—28 February 1907; Torreya VII: 83. Apr. 1907.

2) BESSEY, ERNST A.: The Florida strangling Figs. 19th. Rep. Mo. Bot. Gard. 1908: 25—33 with 9 plates.

3) In addition to the above text references see CURTISS, A. H.: The fern Flora of Florida. Fern Bulletin XII: 33—38 April 1904; Flora of the Florida Keys. Garden and Forest I: 279; BRITTON, N. L.: Explorations in Florida and the Bahamas. Journal New York Botanical Garden V: 129—136 July 1904; SMALL, J. K.: Report on Exploration in tropical Florida. Journal New York Botanical Garden V: 49—53 March 1904; GARBER, A. P.: The April Flora of Cedar Keys, Fla. Botanical Gazette II: 112; CALKINS, W. W.: Notes on the winter Flora of Florida. Botanical Gazette II: 128; SMALL, J. K. and NASH, GEO. V.: Report upon a Trip to Florida. Journal New York Botanical Garden III: 29—35 Feb. 1902; DIX and MACGONIGLE: The Everglades of Florida. Century Magazine Feb. 1905; WEBBER, H. J.: The water Hyacinth, Bulletin 18. U. S. Division Botany. 1897; DIMOCK, A. W.; On to Marco Pass. The Outing Magazine LIII: 397—412, Jan. 1909; COCHRANE, J. S.: A Cruise to Okeechobee. Recreation Mch. 1909: 105; SMALL, J. K.: Exploration in the Everglades. Torreya IX: 100—103. May 1909.

## 3. Bermudan Region.

This region comprehends the archipelago of larger and smaller islands lying south of the Gulf Stream in the western Atlantic between 32° 14′ and 32° 23′ N. latitude and 64° 38′ and 64° 53′ W. longitude, thus being about 600 miles from the nearest land, Cape Hatteras in North Carolina. This region is placed in our classification in the West Indian section because its flora shows affinities to that region, but yet the vegetation is distinct enough with its thirten endemic species to merit its separation into a Bermudan region with such plants as *Erigeron Darrelianus* and *Carex bermudiana* with no living American relatives. It is evident from a study of the composition of the Bermudan flora, that it is of comparatively recent introduction. Briefly, says HEMSLEY[1]): "it is not of purely West Indian origin, but was derived from the West Indies and that region of south-eastern North America where the West Indian and North American types of vegetation overlap each other". BRITTON emphasizes the fact that the flora is almost wholly West Indian and Floridan.

There being no running streams, the original flora of Bermuda was essentially of a xerophytic type. The islands have been settled so long that the character of the original vegetation has been altered and we must infer from the appearance of the flora at the present what its condition was when the Bermudas were first discovered. The following formations according to the observations of the writer[2]) in June 1905 may be distinguished.

*Marine Algal Formation.* The marine algae of Bermuda are mainly those which have accustomed themselves to living on a shore composed of limestone rocks (reef rocks, or eolian rocks) exposed to the action of the surge or which live in a limestone, or coral sand in the comparatively placid water of salt water lakes, bays, or lagoons.

According to my observations, the algae of the rocks exposed to the surge are *Sargassum bacciferum*, *Halimeda tridens*, *H. tuna*, *Avrainvillea nigricans*, *Anadyomene flabellata*, *Codium tomentosum*, *Neomeris dumetosus*, *Ulva lactuca*, *U. latissima*, *Rhodymenia palmata*, *Padina pavonia* and others. Those of the tidal pools formed in the rock hollows are: *Padina*, *Digenea simplex*, *Acetabularia crenulata*, *Caulerpa crassifolia*, *C. racemosa* var. *occidentalis*, *Ulva* etc. The sandy bottoms beneath mangrove trees, or in the channels leading from salt-water sounds, or ponds to the sea are characterized by *Halimeda tridens*, *Penicillus capitatus*, *Caulerpa cupressoides* var. *mamillosa*, *Padina*. The salt

1) HEMSLEY, W. B.: Report on the Botany of the Bermudas Challenger Report Botany I: 14; MOORE, A. H.: List of Plants collected in Bermuda in 1905; 22 pages Cambridge March 12, 1906; BRITTON, N. L.: Bermuda in September Journal New York Botanical Garden VI: 154; SMALL, H. B.: Botany of Bermuda, 56 pages. 1900.

2) HARSHBERGER, J. W.: The plant Formations of the Bermuda Islands Proceedings Academy Natural Sciences of Philadelphia 1905: 695—700; The hour-glass Stems of the Bermuda Palmetto do. 701—704. The Comparative Leaf Structure of the Sand Dune Plants of Bermuda. Proceedings American Philosophical Society XLVII: 97—110.

water ponds, especially at Walsingham, are fed by underground channels so that the water in them rises and falls with the tide. Here grow several interesting marine algae, such as: *Valonia utricularis*, *Caulerpa plumaris*, *C. racemosa* and *Colpomenia sinuosa*. *Thalassia testudinum* grows in all shallow bays.

*Mangrove Formation.* The mangrove swamps occur at the heads of bays especially along the south shore of the Bermudas and in the salt water ponds which are here and there found distributed over the islands. The vegetation consists either of a pure growth of *Rhizophora mangle* with its prop roots extending in all directions, or a pure growth of *Avicennia nitida* (in flower in June) with its numerous asparagus-like root knees projecting through the sticky mud at low tide. In some places, as in Castle Harhor, both *Avicennia* and *Rhizophora* are in association and frequently one finds arising from the mud the green brush-like tops of *Penicillus capitatus*. Little else grows beneath the dense shade formed by the overarching crowns of these trees. Frequently a morass is formed by either *Rhizophora*, or *Avicennia* taking possession of a shallow inland pond which thus becomes a swamp.

*Salt Marsh-* and *Brackish Marsh Formation.* This is found at the head of bays and elsewhere where the soil is influenced hy the tides. In such a marsh along Harrington Sound the writer noted *Salicornia ambigua*, *Heliotropium curassavicum*, *Sesuvium portulacastrum*, a number of sedges and a single tree of *Avicennia*. The rare *Statice Lefroyi*, identic with *Statice Limonium* var. *carolinianum* is a salt marsh plant. The Brackish Marsh Formation exists in depressions some distance inland, where marshes occur, such as Smiths Parish Marsh, Devonshire Marsh, Pembroke Marsh, all of which were investigated by me. Paget Marsh was visited by N. L. BRITTON and STEWARDSON BROWN[1]).

Smiths Parish Marsh is devoid of trees. Here in the soil rendered brackish by underground channels grow Typha angustifolia in pure association, Baccharis glomeruliflora, Myrica cerifera in thickets, Dichromena colorata, Scirpus lacustris, while Osmunda cinnamomea is frequent. Acrostichum aureum forms pure associations at the edge of this marsh. — Devonshire Marsh is a large area with a few pools of water in the depressions. It gives evidence that it was once a pond. Juniperus Bermudiana, Sabal Blackburniana and Baccharis glomeruliflora have encroached on this marsh so as to shade it. On the ground in the wettest places according to COULTER[2]) are Hydrocotyle asiatica, Herpestis Monniera, Mentha viridis, M. piperita and a white hracted sedge, Dichromena colorata. On the drier ground, Osmunda regalis and O. cinnamomea become abundant, while in the still drier peaty soil, according to my observations, Pteris aquilina var. caudata is growing vigorously. Typha angustifolia is in some places in pure association. Acrostichum aureum also forms pure associations here and there in this marsh. The pools are occupied by two species of Sphagnum, Proserpinaca palustris and Lemna minor[3]).

1) BROWN, STEWARDSON, Notes on the Flora of the Bermudas. Proc. Acad. Nat. Sci. 1909: 486—494.

2) COULTER, S. M.: An ecological Comparison of some typical Swamp Areas. 15th Report Missouri Bot. Garden 1904: 62.

3) According to N. L. BRITTON and STEWARDSON BROWN who visited the islands August 31 —September 20, 1905, it is Lemna cyclotosa.

Pembroke Marsh is characterized by somewhat similar associations of plants, such as Panicum crus-galli, Cyperus flavescens, Ranunculus repens, Proserpinaca palustris, Ludwigia (Isnardia) palustris, but in addition to the plants noticed above Governor LEFROY[1]) mentions several other plants peculiar to it, f. e. Spiranthes brevilabris, the only orchid of Bermuda. The omnipresent cedar is found along the edges of this marsh together with Sabal Blackburniana which invades it. In a small pool grows Lemna minor and in Paget Marsh, Carex bermudiana.

*Dune Formation.* Sand dunes occur typically along the south shore of Bermuda at the head of reentrant bays between stretches of rocky coast. Several low dunes are found on the north shore, as at Shelly Bay. The middle beach is covered with masses of *Sargassum*, washed ashore at high tide.

The upper beach at the foot of the dunes is characterized by the presence of Cakile lanceolata, occasional clumps of Tournefortia gnaphalodes, Scaevola Plumieri, and Croton punctatus. Ipomoea pes-caprae sends its long runners down from the slopes of the dunes, associated with Scaevola Plumieri, Stenotaphrum americanum. A little back of the crest of the dunes are found Tournefortia gnaphalodes, Ipomoea pes-caprae, Scaevola Plumieri, Juniperus bermudiana (windswept form) Sisyrynchium bermudianum, Lepidium virginicum, Euphorbia buxifolia, Canavalia obtusifolia, Opuntia vulgaris. On the dunes at Tuckertown, Scaevola Plumieri forms extensive tracts in pure association (Scaevola Association) with Alsine Baldwinii. Solidago sempervirens, as in the eastern United States, is also a dune plant together with the glaucous and hairy forms of Borrichia arborescens and Dodonaea viscosa. Conocarpus erectus forms thickets which in some places protects the dune crest. Here we have a mangrove plant occuring on sand dunes under perhaps similar ecologic conditions as in salt water.

Sea Cliff Formation. The coast line of Bermuda is generally rocky and the waves have honeycombed the rocks into jagged forms with sea caves hollowed out beneath. These rocks support a characteristic vegetation consisting of Matthiola incana, Suriana maritima, Borrichia arborescens, B. frutescens, prostrate trees of Conocarpus erectus, clumps of Solidago sempervirens, Lantana involucrata, L. camara, Euphorbia buxifolia, the crab grass Stenotaphrum americanum (covering all the available soil on the rocks), while wind-swept trees of Juniperus bermudiana, Yucca aloifolia and dwarf palmettos, Sabal Blackhurniana also abound in some places. Coccoloba uvifera in Bermuda seems to prefer the rocky shores to those of sand. Sesuvium portulacastrum and Lippia nodiflora are also rock plants.

*Cedar Forest Formation.* This formation has been signified by the name "forest", although no true forest exists on the islands, for the reason that the growth of the cedar trees *Juniperus bermudiana* is too open and the trees are not tall and dominant in the forest sense. However, all of the hillsides and hill summits not under cultivation are covered with this cedar with the admixture of *Forestiera porulosa*, *Sabal Blackburniana*, *Chiococca bermudiana*, *Ilex vomitoria* (= *I. cassine*, *Eugenia axillaris*, *Borreria laevis*, *Zanthoxylum flavum* (rare).

This species of juniper is a rapid growing one and reaches a merchantable size (2—3 feet in diameter), hut it differs from the eastern American species (J. virginiana) in hranching much more freely. It produces fruit in abundance. It is hard to determine the character of the original undergrowth. Now it consists of two species of Lantana (L. involucrata, L. camara), the prevailing exotic Nerium oleander, Lippia nodiflora, Galium bermudense, Solidago sempervirens and Sisyrynchium bermudianum. The rock crevices are filled with delicate endemic fern, Adiantum

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1) LEFROY, Governor Sir J. H.: The Botany of Bermuda. Bulletin U. S. National Museum No. 25, 1884.

bellum. Bryophyllum calycinum (the floppers of the natives) is perhaps the most abundant plant in the undergrowth. It is found in all parts of the islands. The ground beneath the cedars is carpeted with the crab grass Stenotaphrum americanum in the absence of other plants. Here and there the botanist meets with an introduced tree, which enter into this formation and change its constitution.

*Limestone Sinks.* The so-called Walsingham Tract and several places near Harrington Sound on the south shore are characterized by the presence of numerous depressions, or sinks, as well as several caves. The Walsingham Tract, a narrow ridge of land about two miles long and from a quarter to half a mile wide which separates Castle Harbor from Harrington Sound, contains within its bounds nearly the whole of the indigenous flora of the islands including the rarest trees of the islands, viz., the olive wood *Elaeodendron Laneanum*, yellow wood *Fagara flava* and red mulberry, *Morus* sp.

According to my observations, the following trees form a large part of the vegetation of one of the sinks: Celtis mississippiensis, Citrus limonium, Ficus carica, Musa Cavendishii (= M. chinensis, planted), Melia azedarach, Lantana camara, L. odorata, while Stenotaphrum americanum abounds and Asplenium trichomanes together with Rhus toxicodendron are found on the sloping sides of such depressions. Several vines are abundant and loop themselves across the trees, viz.: *Cardiospermum microcarpum. Phaseolus lunatus and Jasminum gracile; Commelina agraria* also occurs in such sinks. The cave-like sinks are characterized, according to the recent observations of N. L. Britton and Stewardson Brown, by such ferns as Dryopteris (Aspidium) ampla, Adiantum bellum, Pteris longifolia, Asplenium muticum, Diplazium laffanianum.

At Walsingham, Juniperus bermudiana prevails mixed with Sabal Blackburniana, Celtis mississippiensis, Citharexylum quadrangulare, Calophyllum calaba, Adelia segregata, Psychotria undata, Trema Lamarckiana, Eugenia monticola etc., while the trees are festooned with Jasminum gracile, Rhus toxicodendron and Ipomoea purpurea. Peperomia septentrionalis (= magnoliaefolia) and several ferns are found on the rough rocks in the bottom of the sinks, together with Bryophyllum calycinum and one or two species of Lantana.

A Scrub Formation is due to the hand of man. After the cedars are cut down, if the land is neglected and allowed to stand without cultivation it is covered by a growth of several species of Lantana, presumably Lantana camara and L. involucrata. Bryophyllum calycinum also abounds, together with many introduced weeds and thickets of Nerium oleander. Many of the hillsides in Bermuda are covered with this worthless scrub. Later perhaps under favorable conditions Juniperus bermudiana appears, but the flora is never restored to its original condition, because the sage brush plants always form an important constituent of the undergrowth.

# Index of Plants.

The details of synonymy omitted in the text are given in this index. It also supplies exact data as to the habitats, or stations, of many North American plants, thus furnishing geographic details which our manuals of botany do not give. The index comprises 7400 scientific names of plants.


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